

Third Edition

Exotic Animal Formulary



James W. Carpenter

Exotic Animal Formulary, 3rd Edition

Exotic Animal Formulary

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3rd ed.

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TABLE 1 Antimicrobial and antifungal agents used in fish.^{a–f}

Agent	Dosage	Comments
Amikacin	5 mg/kg IM q12h ⁴³ 5 mg/kg IM q72h ×3 treatments ⁵⁰ 5 mg/kg ICe q24h ×3 days, then q48h ×2 treatments ²¹	Koi
Amoxicillin	— 25 mg/kg PO q12h ⁴⁵ 40–80 mg/kg/day in feed ×10 days ³¹	Rarely indicated in aquarium fish because few pathogens are gram positive
Ampicillin	10 mg/kg q24h IM ^{3,48} 50–80 mg/kg/day in feed ×10 days ³¹	Rarely indicated in aquarium fish because few pathogens are gram positive
Aztreonam (Azactam, Squibb)	100 mg/kg IM, ICe q48h ×7 treatments ²⁴	<i>Aeromonas salmonicida</i> ; used by koi hobbyists
Benalkonium chloride	0.5 mg/L long term ⁴⁸ 10 mg/L for 10 min ⁴⁸	Quaternary amine with broad disinfection properties
Bronopol (Pyceze, Novartis)	15–50 mg/L ×30–60 min bath ^{34,50}	For mycotic infections (eggs and fish); eggs may require the higher dose
Ceftazidime (Fortaz, Pfizer)	22 mg/kg IM, ICe q72–96h ×3–5 treatments ³⁶	Cephalosporin with good activity against gram-negative bacteria (e.g., <i>Pseudomonas</i>)
Chloramine-T	2.5–20 mg/L as flush treatment ^{6,48}	Disinfectant; used to control bacterial gill disease and some ectoparasites; dosage and duration vary widely with species and water quality
Chloramphenicol	— 50 mg/kg PO, IM once, then 25 mg/kg q24h ⁴⁵ 20–40 mg/kg IM, ICe q48h ×7 treatments ²⁴ 20–50 mg/kg ICe q7d ×2 treatments ³¹	Florfenicol may be a better alternative (risk to humans from chloramphenicol) <i>A. salmonicida</i> in goldfish
Enrofloxacin (Baytril, Bayer)	2.5–5.0 mg/L ×5 hr bath q24h ²⁹ ×5–7 days ²⁴ 5 mg/kg PO, IM, ICe q24h ⁴⁵	Red pacu/PD ²⁹ ; change 50%–75% of water between treatments
	5–10 mg/kg PO q24h ×10–14 days ²⁴ 5–10 mg/kg PO q24h ⁴⁸ 5–10 mg/kg IM, ICe q48h ²⁹ ×7 treatments ²⁴ 10 mg/kg ICe q96h ×4 treatments ²⁸ 0.1% feed ×10–14 days ²⁴ 10 mg/kg PO in feed q24h ⁴²	Red pacu/PD ²⁹ Rainbow trout Koi at 21°C (70° F)/PD ²⁸ Oral or injectable form can be given orally Atlantic salmon/PD
Erythromycin	— 50–100 mg/kg PO q24h ×10 days ²⁴ 100 mg/kg PO, IM q24h ×7–21 days ^{45,48} 100–200 mg/kg PO q24h ×21 days ³⁰	Commonly sold as tank treatment for aquarium fish; not recommended because of toxicity to nitrifying bacteria ³¹ Salmonids/to control <i>Renibacterium salmoninarum</i>
Florfenicol (Nuflor, Schering Plough)	5–20 mg/kg PO q24h ¹⁹ 40–50 mg/kg PO, IM, ICe q12–24h ^{27,45}	Atlantic salmon/PD ¹⁹ Red pacu/PD ²⁷

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Flumequine	50–100 mg/L × 3 hr bath ³¹ 10 mg/kg q24h in feed × 10 days ³¹ 10 mg/kg PO q48h ¹¹ 30 mg/kg IM, ICe ³¹	Quinolone; gram-negative bacteria; freshwater fish at pH 6.8–7.2; decreased uptake in hard water; increase dose for marine fish Cod, goldsinny wrasse/PD ¹¹ High antibiotic levels for several days when given IM	6
Formalin	All doses based on volumes of 100% formalin (= 37% formaldehyde) 0.23 mL/L bath up to 60 min ³¹ 1 mL/38 L as 12–24 hr bath followed by 30%–70% water change, may be repeated ⁸ 1–2 mL/L bath, up to 15 min ³¹ (for eggs only)	Mycotic infections on eggs; do not treat within 24 hr of hatching; caution: carcinogenic; do not use if highly toxic white precipitates of paraformaldehyde are present; some fish are very sensitive; test on small number first, monitor fish for respiratory distress and pale color; increased toxicity in soft, acid water and at high temperature; treat with vigorous aeration because of oxygen depletion; toxic to plants	
Furazolidone	1–10 mg/L tank water for ≥ 24 hr ³¹ 25–35 mg/kg q24h in feed for 20 days ¹⁸ 50–100 mg/kg q24h in feed × 10–15 days ³¹	Nitrofurantoin; caution: carcinogenic; toxic to scaleless fish; absorbed from water; drug inactivated in bright light Some salmonids/not approved for fish intended for human consumption in the United States	7
Gentamicin	2.5 mg/kg IM q72h ⁴⁵	Nephrotoxic; substantial risk in species for which dosages have not been determined ³⁷	
Iodine, potentiated (Betadine, Purdue Frederick)	Topical to wound; rinse immediately ³¹ 20–100 mg/L for 10 min ⁴⁸	Do not use solutions combined with detergent (e.g., Betadine scrub) For disinfecting eggs (available iodine)	7
Itraconazole (Sporanox, Janssen)	1–5 mg/kg q24h in feed q1–7d ⁴⁵	Systemic mycoses	
Kanamycin sulfate (Kantrex, Adothecon)	50–100 mg/L × 5 hr bath q72h × 3 treatments ²⁴ 50 mg/kg q24h in feed ³¹ 20 mg/kg ICe q3d × 5 treatments ³¹	Change 50%–75% of water between treatments; absorbed from water Toxic to some fish	
Ketoconazole	2.5–10.0 mg/kg PO, IM, ICe ⁴⁵	Systemic mycoses	
Malachite green (zinc-free)	— 0.1 mg/L tank water q3d × 3 treatments ³¹ 0.25 mg/L × 15 min q24h ⁵¹ 0.5 mg/L × 1 hr bath ³¹ 1 mg/L × 30–60 min bath ³¹	Freshwater fish/mycotic infections; caution: mutagenic, teratogenic; toxic to some fish species and to fry; increased toxicity at higher temperatures and lower pH; stains objects, especially plastic; toxic to plants; not approved for use on fish intended for human consumption Remove residual chemical with activated carbon after final treatment For fungal control on fish eggs Freshwater fish eggs Use 2 mg/L if pH is high	
	1 mg/L × 1 hr ⁴⁸ 2 mg/L × 15 min q24h ⁴⁸ 10 mg/L × 10–30 min bath ³¹ 50–60 mg/L × 10–30 sec bath ³¹ 100 mg/L topical to skin lesions ³¹	For fungal control on fish eggs For fungal control on fish eggs Freshwater fish eggs	8
Methylene blue	2 mg/L tank water q48h, up to 3 treatments ³¹	Prevents infections of freshwater eggs; toxic to nitrifying bacteria; stains many objects; toxic to plants	

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Miconazole (Monistat, Janssen)	10–20 mg/kg PO, IM, ICe ⁴⁵	Systemic mycoses	
Naladixic acid (Neg Gram, Sanofi Winthrop)	5 mg/kg PO, IM q24h ⁴⁵ 5 mg/kg PO, IV q24h ²⁰ 20 mg/kg q24h ⁴⁸ 13 mg/L ×1–4 hr bath, repeat prn ³¹	Quinolone; gram-negative bacteria Rainbow trout/PD ²⁰	
Neomycin	66 mg/L tank water q3d, up to 3 treatments ³¹	Commonly sold as tank treatment for aquarium fish; toxic to nitrifying bacteria; keep fish densities low	
Nifurpirinol	0.1 mg/L tank water q24h ×3–5 days ³¹ 0.45–0.90 mg/kg PO q24h ×5 days ³¹ 1–2 mg/L ×5 min–6 hr bath ³¹ 4–10 mg/kg in feed q12h ×5 days ³²	Nitrofurantoin; caution: carcinogenic; toxic to scaleless fish; absorbed from water; drug inactivated in bright light	
Nitrofurazone	2–5 mg/L tank water q24h × 5–10 days ⁵⁰ 100 mg/L ×30 min bath ³¹ 20 mg/L ×5 hr bath q24h ×5–7 days ²⁴	Nitrofurantoin; caution: carcinogenic; toxic to scaleless fish; absorbed from water; drug inactivated in bright light; water-soluble formulations preferred Change 50%–75% of water between treatments	8
Oxolinic acid	25 mg/L ×15 min bath q12h ×3 days ³¹ 1 mg/L tank water ×24 hr ³¹ 5–25 mg/kg PO q24h ⁴⁵ 10 mg/kg q24h in feed ×10 days ³¹ 10 mg/kg q24h PO ⁴⁸ 25–50 mg/kg q24h PO ⁴⁸	Quinolone; gram-negative bacteria; decreased uptake in hard water; better uptake pH <6.9 Up to 30 mg/kg/day in seawater Freshwater species/PD in many species Marine species	9
Oxytetracycline	10–50 mg/L ×1 hr bath ³¹ 10–100 mg/L tank water ³¹ 20–50 mg/L ×5–24 hr bath q24h ×5–7 days ²⁴ 7 mg/g feed q24h ×10 days ⁴⁹ 55–83 mg/kg/day in feed ×10 days ³¹ 20 mg/kg PO q8h ⁴⁵ 50 mg/kg PO q24h ×10 days ²⁴ 70 mg/kg PO q24h ×10–14 days ⁴⁹ 25–50 mg/kg IM, ICe ³¹ 10 mg/kg IM q24h ⁴⁵ 25 mg/kg IM, ICe q24h ×5–7 days ²⁴ 7 mg/kg IM q24h ⁷ 3 mg/kg IV q24h ⁷ 20 mg/kg ICe ⁴⁸ 60 mg/kg IM q7d ¹⁰ 75 mg/kg PO q24h in feed ×10 days ⁴⁸	Surface bacterial infections; yellow-brown foam may develop in treatment water Higher doses in hard water; if fish still sick, retreat on day 3 after 50% water change; drug light sensitive; keep tank covered to prevent photo-inactivation; drug turns dark brown when decomposing; change 50% of water immediately Change 50%–75% of water between treatments Produces high levels for several days when given IM Red pacu/PD ⁷ Red pacu/PD ⁷ Some salmonids Carp/PD ¹⁰	9

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Potassium permanganate	2 mg/L as an indefinite bath ⁵⁰	Heavily organic systems may require a higher dose; test efficacy by adding the appropriate amount of KMnO ₄ to a small amount of system water (without fish); red color should remain for at least 4 hr (if not, then KMnO ₄ should be added until the 4 hr test is completed)	10
	5 mg/L × 30–60 min bath ³¹	Freshwater fish/skin and gill bacterial infections; toxic in water with high pH; do not mix with formalin; can be toxic in goldfish ⁴³	
	1000 mg/L × 10–40 sec bath ³¹		
Sarafloxacin (Saraflox, Abbott)	10–14 mg/kg PO q24h × 10 days ⁴⁵	Fluoroquinolone	
	10 mg/kg PO q24h ⁴⁸	Marine Atlantic salmon	
Silver sulfadiazine cream (Silvadene, Marion Merrill Dow)	Topical q12h ²⁶	External bacterial infection; keep lesion out of water 30–60 sec after application; keep gills submerged	
Sulfadimethoxine/ormetoprim (Romet, Hoffman-LaRoche)	50 mg/kg/day in feed × 5 days ³¹	Available as a powder to add to feed and as medicated feed	
	Medicated brine shrimp ³¹	Place brine shrimp nauplii (larvae) in 3 mg/L seawater for 4 hr, rinse in seawater with brine shrimp net, then feed immediately to fish; may also work with adult brine shrimp and other live feeds ³¹	
Trimethoprim/sulfamethoxazole	20 mg/L × 5–12 hr bath q24h × 5–7 days ²⁴	Change 50%–75% of water between treatments	10
	30 mg/kg PO q24h × 10–14 days ²⁴		
	0.2% feed × 10–14 days ²⁴		
Triple antibiotic ointment (polymyxin B sulfate/bacitracin/neomycin sulfate)	Topical q12h ²⁴	External bacterial infection; keep lesion out of water 30–60 sec after application; keep gills submerged	11
<p>a Not to be used in fish for human consumption.</p> <p>b Preferable to treat a single fish of a species (biotest) to determine toxicity.</p> <p>c Tank treatment: When treating the fishes' resident aquarium, disconnect activated carbon filtration to prevent drug removal. Many drugs adversely affect the nitrifying bacteria, so water quality should be monitored closely (especially ammonia and nitrite concentrations). Always keep water well aerated and monitor fish closely. Perform water changes and reconnect filtration to remove residual drug following treatment. Discard carbon following drug removal.</p> <p>d Bath treatment: Remove fish from resident aquarium and place in container with known volume of water and concentration of therapeutic agent. Watch closely for signs of toxicity, e.g., listing and dyspnea. Always keep water well aerated.</p> <p>e Species of fish, temperature, and water-quality parameters can influence the pharmacodynamics of many drugs, especially antimicrobials.</p> <p>f For more information, refer to the website in Appendix 2,³⁸ compliments of R. Reimschuessel.</p>			

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TABLE 2 Antiparasitic agents used in fish. ^{a-d}

Agent	Dosage	Comments
Acetic acid, glacial	2 ml/L ×30–45 sec bath ²⁷	Monogenean trematodes, crustacean ectoparasites; safe for goldfish; may be toxic to smaller tropical fish
Chloramine-T	—	See Table 1
Chloroquine diphosphate	10 mg/L tank water, once ³¹	<i>Amyloodinium ocellatum</i> ; monitor for 21 days, retreat prn; use activated carbon to remove drug if no relapse
Closantel (50 mg/ml)/mebendazole (75 mg/ml) (Supaverm, Janssen)	1 ml/400 L ×1 treatment; may repeat in 3–7 days after a water change if necessary ⁵⁰	Very safe and effective in koi for external monogeneans; reported to be highly toxic to goldfish and medaka; used in the United Kingdom to kill digenean trematodes of sheep
Copper sulfate	— 100 mg/L ×1–5 min bath ⁵ 0.1–0.2 mg/L ⁴⁸ Maintain free-ion levels at 0.15–0.2 mg/L tank water until therapeutic effect ³¹ Maintain copper levels at 0.2 mg/L tank water ×14–21 days ⁴⁹ Maintain free-ion levels at 0.25–1.0 mg/L ×24–48 hr bath ¹²	Marine fish/protozoan, trematode ectoparasites; copper levels must be assessed with a commercial kit and adjusted as needed; toxic to gill tissue; immunosuppressive; extremely toxic to invertebrates and many plants; copper removed by activated carbon Prepare stock solution of 1 mg/ml (1 g CuSO ₄ · 5 H ₂ O in 250 ml distilled water) Use higher dose in hard water Citrated copper sulfate; prepare stock solution of 1 mg/ml (3 g CuSO ₄ · 5 H ₂ O and 2 g citric acid monohydrate in 750 ml distilled water) ¹²
Diflubenzuron (Dimilin, Union Carbide)	0.01 mg/L tank water ×48 hr q6d ×3 treatments ⁴³	Crustacean ectoparasites; inhibits chitin synthesis; drug persists in water long term; marketed for control of terrestrial insects; may need EPA license for use in United States
Dimethyl phosphonate	—	See trichlorphon
Dimetridazole	28 mg/kg in feed q24h ×10 days ³⁵	Rainbow trout/for treating <i>Ichthyophthirius multifiliis</i> ; not available in United States
Fenbendazole	2 mg/L tank water q7d ×3 treatments ³¹ 0.2% in feed ×3 days, repeat in 14–21 days ²⁵ 2.5 mg/g feed ×2–3 days, repeat in 14 days ⁴⁹ 40 mg/kg in feed q4d ×2 treatments ⁴⁸ 50 mg/kg PO q24h ×2 days, repeat in 14 days ⁴⁹ Medicated brine shrimp	Nonencysted gastrointestinal nematodes Carp/ <i>Bothriocephalus acheilognathi</i> Place live brine shrimp in 400 mg fenbendazole per 100 ml water ×15–20 min immediately before feeding to fish; feed 2 consecutive days and repeat in 14 days ⁴⁹

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Formalin	— All doses based on volumes of 100% formalin (= 37% formaldehyde) 0.015–0.025 mL/L tank water ³¹ 0.125–0.25 mL/L, up to 60 min bath, repeat q24h ×2–3 days prn ³¹ 0.4 mL/L up to 1 hr bath q3d, up to 3 treatments ⁴³ 0.5 mL/L up to 1 hr bath q3d, up to 3 treatments ⁴³	Formalin combination follows Protozoan, trematode, crustacean ectoparasites; caution: carcinogenic; do not use if highly toxic white precipitates of paraformaldehyde are present; some fish are very sensitive: test on small number first, monitor for piping and pale color; increased toxicity in soft, acid water and at high temperature; treat with vigorous aeration because of oxygen depletion; toxic to plants For <i>Ichthyophthirius</i> , use 0.025 mL/L tank water q48h ×3 treatments; change up to 50% of water on alternate days When using maximum dose, treat q3d Soft water Hard water	13
Formalin (F)/malachite green (M)	(F) 0.025 mL/L +(M) 0.1 mg/L tank water q48h ×3 treatments ³¹	Combination synergistic for <i>Ichthyophthirius</i> ; change up to 50% water on alternate days; several premixed commercial products available	14
Freshwater	3–15 min bath, repeat q7d prn ³¹ 4–5 min bath ²⁵	Marine fish/ectoparasites; aerate well; monitor closely; some small fish are sensitive	
Hydrogen peroxide (3%)	1.0–1.5 mg/L ×20 min bath ⁴⁷ 17.5 mL/L ×4–10 min bath, once ¹²	Atlantic salmon/sea lice Ectoparasites; monitor closely; may be harmful to smaller fish	
Ivermectin	—	Do not use; neurologic signs and death at therapeutic doses ¹² ; toxic to many environmental invertebrates ⁴⁸	
Levamisole (Levasole, Schering Plough)	0.5 mg/kg ICe ²² 1–2 mg/L ×24 hr bath ¹² 10 mg/kg PO q7d ×3 treatments ¹² 11 mg/kg IM q7d ×2 treatments ¹² 50 mg/L ×2 hr bath ¹² 4 g/kg feed q7d ×3 treatments ¹²	Rainbow trout/immunostimulant Internal nematodes, especially larval External trematodes	
Luferuron	0.13 mg/L prn	Control of crustacean parasites ^e	
Malachite green	— 100 mg/L topical to skin lesions ³¹ 0.1 mg/L tank water q3d ×3 treatments ³¹ 50–60 mg/L ×10–30 sec bath ³¹ 1 mg/L ×30–60 min bath ³¹	See formalin for combination Freshwater fish/protozoan ectoparasites; prepare stock solution of 3.7 mg/mL (1.4 g malachite green in 380 mL water); caution: mutagenic, teratogenic; toxic to some fish species (e.g., tetras) and fry; increased toxicity at higher temperatures and lower pH; toxic to plants; stains objects, especially plastic; remove residual chemical with activated carbon after last tank treatment Use 2 mg/L if pH high	
Mebendazole	1 mg/L ×24 hr bath ¹² 1 mg/L for 72 hr ⁴ 20 mg/kg PO q7d ×3 treatments ⁴⁵ 100 mg/L ×10 min–2 hr bath ¹²	Monogenean trematodes European eels/branchial monogeneans (<i>Pseudodactylogyrus bini</i> and <i>P. anguillae</i>) Gastrointestinal nematodes; do not administer to brood fish: embryotoxic and teratogenic Monogenean trematodes	14 15
Methylene blue	1–3 mg/L tank water ³¹	Freshwater fish/ectoparasites; not recommended because of poor efficacy; toxic to nitrifying bacteria; stains objects; toxic to plants	

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Metronidazole	6.6 mg/L tank water q24h ×3 days ³¹ 25 mg/L tank water q48h ×3 treatments ³¹ 25 mg/kg q24h in feed ×5–10 days ³¹ 100 mg/kg q24h in feed ×3 days ³¹ 6.25–18 mg/g feed ×5 days ⁴⁹ 50 mg/kg PO q24h ×5 days ¹² Medicated brine shrimp	<i>Spironucleus (Hexamita)</i> and other internal flagellates; some external flagellates; poorly soluble in water; dissolve before adding to water or feed; change water between tank treatments Equivalent to 0.25% in feed (250 mg/100 g food) at 1% BW/day Equivalent to 1% in feed (1 g/100 g food) at 1% BW/day Place live brine shrimp in 625 mg metronidazole per 100 ml water ×15–20 min immediately before feeding to fish; feed 5 consecutive days ⁴⁹	
Piperazine	10 mg/kg q24h in feed ×3 days ³¹	Nonencysted gastrointestinal nematodes; equivalent to 0.1% in feed at 1% BW/day	
Potassium permanganate	5 mg/L ×30–60 min bath ³¹ 100 mg/L ×5–10 min bath ³¹ 1 g/L ×10–40 sec bath ³¹	Freshwater fish/protozoan, crustacean ectoparasites; toxic in water with high pH; do not mix with formalin; can be toxic in goldfish ⁴³	
Praziquantel	5–10 mg/L ×3–6 hr bath, repeat in 7 days ²⁵ 2 mg/L ×2–4 hr ³³ 5 mg/kg PO q24h ×3 treatments ⁴⁸ 2–10 mg/L up to 4 hr bath ⁴⁹	Monogenean trematode ectoparasites, cestodes; aerate water well; some marine fish sensitive; may be toxic to <i>Corydoras</i> catfish For metacercaria Monitor closely for lethargy, incoordination, loss of equilibrium	15
	5–12 mg/g feed ×3 days ⁴⁹ 5 mg/kg PO in feed q7d, up to 3 treatments ⁴⁵ 5 mg/kg PO, ICe, repeat in 14–21 days ²⁵ 50 mg/kg PO once ³¹	Cestodes, some internal digenean trematodes; could be administered in feed Adult cestodes; gavage or give 0.5% in feed at 1% BW/day	16
Pyrantel pamoate	10 mg/kg in feed, once ⁴⁵	Gastric nematodes	
Salt (sodium chloride)	—	Freshwater fish/protozoan, trematode ectoparasites; seawater or artificial sea salts preferred; seawater is normally 30–35 g/L; use noniodized table/rock salts; some anticaking agents in solar salts are highly toxic; species sensitivity is highly variable (some catfish are sensitive); may be toxic to plants Prophylaxis or treatment of ectoparasites For supportive care With salt-sensitive or weak fish, use lower dosage and repeat in 24 hr Fish >100 g only Safe for goldfish and koi in most cases	
	1–5 g/L tank water, indefinitely ³¹ 3 g/L ⁴⁸ 10–30 g/L up to 30 min bath ³¹ 30 g/L for 10 min ⁴⁸ 30–35 g/L ×4–5 min bath ²⁵		
Thiabendazole	10–25 mg/kg in feed, repeat in 10 days ⁴⁵ 66 mg/kg PO, once ⁴⁵	Gastric nematodes; anorexia may be seen (more severe at higher doses), generally resolves within 2–4 days	

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Trichlorfon (dimethyl phosphonate)	—	Caution: organophosphate, neurotoxic, avoid inhalation and skin contact; aerate water well; especially toxic to larval fish and tetras; liquid form marketed for cattle is convenient to dispense Crustacean ectoparasites; change 20%-30% of water 24–48 hr following each treatment	16
	0.5 mg/L tank water q10d ×3 treatments ²⁵		
	0.25 mg/L tank water ³¹	Freshwater fish/use 0.5 mg/L tank water if >27° C (80° F); treat q3d × 2 treatments for <i>Dactylogyrus</i> and other oviparous monogeneans; treat q7d × 4 treatments for anchor worms; single treatment will usually suffice for other copepods, other monogeneans, <i>Argulus</i> , leeches	17
	0.5–1.0 mg/L tank water ³¹	Marine fish/treat q3d × 2 treatments for oviparous monogeneans; use 1 mg/L q48h ×3 treatments for turbellarians; single treatment will usually suffice for copepods (except sea lice), other monogeneans, <i>Argulus</i> , leeches	
<p>a Not to be used in fish for human consumption.</p> <p>b Preferable to treat single fish of a species to determine toxicity.</p> <p>c Tank treatment: when treating the fishes' resident aquarium, disconnect activated carbon filtration to prevent drug removal; many drugs adversely affect the nitrifying bacteria, so water quality should be monitored closely (especially ammonia and nitrite concentrations); always keep water well aerated and monitor fish closely; perform water changes and reconnect filtration to remove residual drug following treatment; discard carbon following drug removal.</p> <p>d Bath treatment: remove fish from resident aquarium and place in container with known volume of water and concentration of therapeutic agent; watch closely for signs of toxicity, e.g., listing and dyspnea; always keep water well aerated.</p> <p>e Saint-Erne, N. Personal communication. 2004.</p>			

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TABLE 3 Chemical restraint/anesthetic agents used in fish.^{a-c}

Agent	Dosage	Comments
Atipamezole (Antisedan, Pfizer)	0.2 mg/kg IM ¹⁴	Reversal agent (α_2 antagonist) for medetomidine
Benzocaine	— 15–40 mg/L bath ³¹ 50–500 mg/L bath ³¹ 1 g/L spray ³¹	Not sold as fish anesthetic in United States; available from chemical supply companies; do not use topical anesthetic products marketed for mammals; prepare stock solution in ethanol (benzocaine is poorly soluble in water); store in dark bottle at room temperature Transport sedation Anesthesia Large fish/anesthesia; spray onto gills with an aerosol pump sprayer
Butorphanol (Torbugesic, Fort Dodge)	0.05–0.10 mg/kg IM ⁴⁵ 0.4 mg/kg IM ¹⁵	Analgesia, postoperative Postoperative analgesia in koi
Carbon dioxide	—	Euthanasia: bubble gas through water until respiration stops >10 min; other agents preferred ³¹
Clove oil (eugenol)	40–120 mg/L bath ²⁵ 17–25 mg/L ⁴⁸	Stock solution: 100 mg/ml of eugenol by diluting 1 part clove oil with 9 parts 95% ethanol (eugenol is poorly soluble in water); over-the-counter preparation (pure) available at most pharmacies contains approximately 1 g eugenol per ml clove oil; recovery may be prolonged; use lower end of this range to start; many bony fishes readily anesthetized with 25–50 mg/L Aqui-S, a compound mixture of eugenol and polysorbate 80 (for solubility); lower doses (6 mg/L) will produce sedation without general anesthesia ⁴⁸
Ethanol	1.0%–1.5% bath ¹³ >3% bath ¹³	Anesthetic levels difficult to control, resulting in overdose; not recommended Euthanasia; other agents preferred
Etomidate	1–4 mg/L ⁴⁸	Lower doses should be used with striped bass and related species ⁴⁸
Eugenol		See clove oil
Halothane	0.5–2.0 ml/L bath or vaporize then bubble in water ¹³	Anesthetic levels difficult to control, resulting in overdose; not recommended
Isoflurane	0.5–2.0 ml/L bath or vaporize then bubble in water ¹³	Anesthetic levels difficult to control, resulting in overdose; not recommended
Ketamine	— 66–88 mg/kg IM ⁴⁴	Ketamine combination follows Immobilization for short procedures; complete recovery can take >1 hr
Ketamine (K)/medetomidine (M)	(K) 1–2 mg/kg +(M) 0.05–0.10 mg/kg IM ¹³	Immobilization; reverse (M) with atipamezole (0.2 mg/kg IM)
Lidocaine	—	Local anesthetic; use cautiously in small fish; do not exceed 1–2 mg/kg total dose ¹³
Medetomidine	—	See ketamine for combination

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Metomidate (Marinil, Wildlife Pharmaceuticals)	—	Not currently available in United States; stock solution: 10 g/L; store stock in dark container; some fish turn very dark transiently; gouramis may be sensitive; contraindicated in cichlids in water of pH <5	
	0.06–0.20 mg/L water ⁴⁴	Transport sedation	
	0.5–1.0 mg/L water ¹³	Light sedation	
	2.5–5.0 mg/L water ¹³	Heavy sedation	
	5–10 mg/L bath ¹³	Anesthesia; some species require 10–30 mg/L bath	
	2.5–5.0 mg/L bath induction; 0.2–0.3 mg/L maintenance ⁴⁴	Marine fish/anesthesia	
	1–10 mg/L bath induction; 0.1–1.0 mg/L maintenance ⁴⁴	Freshwater fish/anesthesia	
MS-222 (Finquel, Argent)	—	See tricaine methanesulfonate	
Pentobarbital	60 mg/kg ICe ³¹	Euthanasia	
Phenoxyethanol	0.1–0.5 mL/L ⁴⁸ 0.6 mL/L ⁴⁸	Carp/surgery	
Quinaldine sulfate (Current Research Laboratories)	50–100 mg/L bath induction; 15–60 mg/L maintenance ¹³	Anesthesia; not sold as fish anesthetic in United States; stock solution: 10 g/L, buffer the acidity by adding sodium bicarbonate to saturation; store stock in dark container; shelf-life of stock extended by refrigeration or freezing; aerate water to prevent hypoxemia; drug not metabolized, excreted unchanged; euthanasia: keep fish in solution >10 min after respiration stops	19
	25 mg/L ⁴⁸	Channel catfish, salmonids/do not use with largemouth bass; not recommended for long surgical procedures ⁴⁸	20
Sodium bicarbonate	30 g/L bath ³¹	Euthanasia; generates CO ₂ ; use when other agents unavailable; keep fish in solution >10 min after respiration stops; generally not recommended; not an AVMA-approved method of euthanasia	
Sodium bicarbonate tablets (Alka-Seltzer, Bayer)	2 tablets/ 0.5–1.0 L bath ⁸	Euthanasia; generates CO ₂ ; use when other agents unavailable; keep fish in solution >10 min after respiration stops	
Tricaine methanesulfonate (MS-222; Finquel, Argent)	50–100 mg/L bath induction; 50–60 mg/L maintenance ⁴⁴ 100–200 mg/L bath induction; 50–100 mg/L maintenance ¹³ 15–50 mg/L water ¹³ 1 g/L spray ³¹ 8–30 mg/L ¹	Anesthesia; stock solution: 10 g/L, buffer the acidity by adding sodium bicarbonate at 10 g/L or to saturation (unbuffered solution may cause some ectoparasites to leave fish) ⁵ ; store stock in dark container; shelf life of stock extended by refrigeration or freezing; stock that develops an oily film should be discarded; aerate water to prevent hypoxemia; narrower margin of safety in young fish and soft, warm water; euthanasia: keep fish in solution >10 min after respiration stops Sedation Large fish/anesthesia; spray onto gills with an aerosol pump sprayer For sedation of a variety of species	
<p>a Not to be used in fish for human consumption.</p> <p>b Preferable to treat single fish of a species to determine toxicity.</p> <p>c Aerate water during anesthetic procedures; dissolved oxygen concentrations should be maintained between 6 and 10 mg/L.</p>			

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TABLE 4 Miscellaneous agents used in fish.^{a-c}

Agent	Dosage	Comments
Atropine	0.1 mg/kg IM, ICe, IV ⁴³	Organophosphate or chlorinated hydrocarbon toxicity
Carbon, activated	75 g/40 L tank water ³¹	Removal of medications and other organics from water; usually added to filter system; discard after 2 wk; 75 g ≈ 250 cc dry volume
Carp pituitary extract	5 mg/kg IM, repeat in 6 hr ⁴⁵	Dose when combined with human chorionic gonadotropin (20 IU/kg); hormone to stimulate release of eggs (may be given in 2 doses, 24 hr apart; the first "preparatory" dose ≤10% of the total dose); does not cause eggs to mature; do not administer unless eggs are mature
	0.75 mg/kg IM ⁴⁸	Female fish (<2 kg)
	1.0–1.5 mg/kg IM ⁴⁸	Male fish
	1.5 mg/kg IM ⁴⁸	Female fish (2–5 kg)
	2.5–3.0 mg/kg IM ⁴⁸	Female fish (>5 kg)
Chlorine/chloramine neutralizer	Use as directed	See sodium thiosulfate
Dexamethasone	1–2 mg/kg IM, ICe ⁴⁵	Adjunct to treatment of shock, trauma, chronic stress syndromes
	2 mg/kg ICe, IV q12h ²⁵	Chlorine toxicity; may improve prognosis
Doxapram	5 mg/kg ICe, IV ⁴³	Respiratory depression
Epinephrine (1:1000)	0.2–0.5 ml IM, ICe, IV, IC ⁴³	Cardiac arrest
Furosemide	2–5 mg/kg IM q12–72h ⁴⁵	Diuretic; ascites, generalized edema; of questionable value because fish lack a loop of Henle
Glucans (Macrogard, Mackzymal)	2–10 mg/kg ICe ^{39,48}	Polysaccharides; immunostimulant
	2 g/kg of feed ×7 days ⁴¹	Tested with positive results in rainbow trout
Haloperidol	0.5 mg/kg IM ⁴⁵	Dopamine blocking agent; use with LRH-A to stimulate release of eggs
Human chorionic gonadotropin (hCG)	30 IU/kg IM, repeat in 6 hr ⁴⁵	Hormone to stimulate release of eggs; does not cause eggs to mature; do not administer unless eggs are mature
	20 IU/kg IM, repeat in 6 hr ⁴⁵	Dose when combined with carp pituitary extract (5 mg/kg)
	800–1000 IU/kg IM q8h ⁵²	Carp
Hydrocortisone	1–4 mg/kg IM, ICe ⁴⁵	Adjunct to treatment of shock, trauma, chronic stress syndromes
Hydrogen peroxide (3%)	0.25 ml/L water ³¹	Acute environmental hypoxia; see oxygen
LRH-A	2 µg/kg IM, then 8 µg/kg 6 hr later ⁴⁵	Synthetic luteinizing releasing hormone analog; stimulates release of eggs; does not cause eggs to mature; do not administer unless eggs are mature; in species that do not respond to LRH-A alone, administer with haloperidol or reserpine with the first injection of LRH-A
Nitrifying bacteria	Use as directed for commercial products	Seed or improve development of biologic filtration to detoxify ammonia, nitrite, and nitrate; numerous commercial preparations; do not expose products to extreme temperatures; use before expiration date
	Add material (e.g., floss, gravel) from a tank with an active biologic filter and healthy fish to new tank ³¹	Must evaluate risk of disease transmission with this technique
Oxygen (100%)	Fill plastic bag with O ₂ containing 1/3 vol water ²⁵	Acute environmental hypoxia common with transportation; close bag tightly with rubberband; keep fish in bag until normal swimming and respiratory behavior
Reserpine	50 mg/kg IM ⁴⁵	Dopamine blocking agent; use with LRH-A to stimulate release of eggs

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Salt (sodium chloride)	1–3 g/L tank water ²³	Freshwater fish: prevention of stress-induced mortality; seawater or artificial sea salts preferred; use noniodized table/rock salts; some anticaking agents in solar salts are highly toxic; highly variable species sensitivity to salt (some catfish sensitive); may be toxic to plants	22
	3–5 g/L tank water ³¹		
	Add chloride to produce at least a 6:1 ratio (w/w) 31 of Cl:NO ₂ ⁻ ions	Treatment of nitrite toxicity; amount of Cl ⁻ needed (mg/L) = (6 × [NO ₂ ⁻ in water]) – (Cl ⁻ in water); table/rock salt = 60% Cl, artificial sea salts = 55% Cl	23
Sodium thiosulfate	Use as directed for chlorine/chloramine neutralizers	Active ingredient in numerous chlorine/chloramine neutralizers; chlorine and chloramine are common additions to municipal water supplies and are toxic to fish; ammonia released by detoxification of chloramine is removed by functioning biologic filter (see nitrifying bacteria) or chemical means (see zeolite)	
	10 mg/L tank water ²⁵		
	10 g neutralizes chlorine (up to 2 mg/L) from 1000 L water ²⁵		
	100 mg/L tank water ⁴³	Chlorine exposure	
Zeolite (clinoptilite; Ammonex, Argent)	Use as directed	Ion-exchange resin that exchanges ammonia for sodium ions; clinoptilite is an active form of zeolite; used to reduce or prevent ammonia toxicity	
	20 g/L tank water ³¹		
<div>a Not to be used in fish for human consumption.</div> <div>b Preferable to treat single fish of a species to determine toxicity.</div> <div>c Bath treatment: remove fish from resident aquarium and place in container with known volume of water and concentration of therapeutic agent; watch closely for signs of toxicity, e.g., listing and dyspnea; always keep water well aerated.</div>			

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APPENDIX 1 Hematologic and serum biochemical values of fish.^a

Measurements	Goldfish (<i>Carassius auratus</i>) ^{2,9}	Koi (<i>Cyprinus carpio</i>) ^{9,14}
HEMATOLOGY		
PCV (%)	26 ± 1	35 (24–43)
RBC (10 ⁶ /μl)	1.5 ± 0.1	1.67 ± 0.08
Hb (g/dl)	9.1 ± 0.4	82 ± 4
MCV (fl)	—	—
MCH (pg)	—	—
MCHC (g/dl)	—	—
WBC (10 ³ /μl)	—	37.8 ± 2.9
Heterophils (%)	29 ± 3	—
Lymphocytes (%)	70 ± 5	—
Monocytes (%)	1 ± 0.1	—
Azirophils (%)	—	—
Eosinophils (%)	—	—
Basophils (%)	—	—
CHEMISTRIES		
AP (IU/L)	—	—
ALT (IU/L)	106 ± 9	—
Anion gap	—	17 (14–23)
AST (IU/L)	908 ± 102	121 (40–381)
Bicarbonate (mmol/L)	—	6 (3–8)
BUN (mg/dl)	28 ± 0	—
Calcium (mg/dl)	—	8.7 (7.8–11.4)
Chloride (mEq/L)	—	114 (108–119)
Cholesterol (mg/dl)	—	—
Creatine kinase (IU/L)	—	4123 (80–9014)
Creatinine (mg/dl)	—	—
Glucose (mg/dl)	73 ± 9	37 (22–65)
LDH (IU/L)	—	359 (41–1675)
Magnesium (mEq/L)	—	—
Osmolality (mOsm/kg)	—	—
Phosphorus (mg/dl)	—	6.1 (3.5–7.7)
Potassium (mEq/L)	—	3.4 (2.7–4.3)
Protein, total (g/dl)	—	2.0 (1.4–2.7)
Albumin (g/dl)	—	0.9 (0.6–1.1)
Globulin (g/dl)	—	1.1 (0.8–1.6)
A:G (ratio)	—	—
Sodium (mEq/L)	—	134 (112–141)
Total CO ₂ (mmol/L)	—	—
Uric acid (mg/dl)	—	—

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Measurement	Red Pacu (<i>Piaractus brachypomum</i>) ^{40,46}	Bonnethead Shark (<i>Sphyrna tiburo</i>) ¹⁶
HEMATOLOGY		
PCV (%)	26 (22–32)	24 (17–28)
RBC (10 ⁶ /μl)	1.7 (1.2–2.9)	—
Hb (g/dl)	—	—
MCV (fl)	—	—
MCH (pg)	—	—
MCHC (g/dl)	—	—
WBC (10 ³ /μl)	33.5 (13.6–52.3)	—
Heterophils (%)	5.2 (0.3–36.7)	—
Lymphocytes (%)	84 (53–96)	—
Monocytes (%)	4 (0.8–11.2)	—
Azurophils (%)	—	—
Eosinophils (%)	0.3 (0.3–0.7)	—
Basophils (%)	—	—
CHEMISTRIES		
AP (IU/L)	—	—
ALT (IU/L)	—	—
Anion gap	6.9 (1.2–12.5)	–5.8 (–1.5–7.5)
AST (IU/L)	49 (0–125)	42 (15–132)
Bicarbonate (mmol/L)	—	3 (0–5)
BUN (mg/dl)	—	2812 (2644–2992)
Calcium (mg/dl)	10.8 (9.5–12.5)	16.8 (15.8–18.2)
Chloride (mEq/L)	139 (146–159)	290 (277–304)
Cholesterol (mg/dl)	—	—
Creatine kinase (IU/L)	—	82 (18–725)
Creatinine (mg/dl)	0.3 (0.2–0.4)	—
Glucose (mg/dl)	—	184 (155–218)
LDH (IU/L)	238 (65–692)	<5 (<5–11)
Magnesium (mEq/L)	—	—
Osmolality (mOsm/kg)	—	1094 (1056–1139)
Phosphorus (mg/dl)	7.3 (4.1–8.9)	8.8 (5.9–12.7)
Potassium (mEq/L)	3.9 (2.7–5.0)	7.3 (5.7–9.2)
Protein, total (g/dl)	—	2.9 (2.2–4.3)
Albumin (g/dl)	0.9 (0.5–1.0)	0.4 (0.3–0.5)
Globulin (g/dl)	—	2.6 (1.9–3.8)
A:G (ratio)	—	0.1 (0.1–0.2)
Sodium (mEq/L)	150 (146–159)	282 (273–292)
Total CO ₂ (mmol/L)	7.5 (6–10)	—
Uric acid (mg/dl)	—	—

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Measurement	Striped Bass (<i>Morone saxatilis</i>) ^{17,32}	Palmetto Bass (<i>Morone saxatilis</i> x <i>M. chrysops</i>) ³²
HEMATOLOGY		
PCV (%)	42 (34–28)	—
RBC (10 ⁶ /μl)	—	—
Hb (g/dl)	—	—
MCV (fl)	—	—
MCH (pg)	—	—
MCHC (g/dl)	—	—
WBC (10 ³ /μl)	—	—
Heterophils (%)	—	—
Lymphocytes (%)	—	—
Monocytes (%)	—	—
Azurophils (%)	—	—
Eosinophils (%)	—	—
Basophils (%)	—	—
CHEMISTRIES		
AP (IU/L)	—	—
ALT (IU/L)	—	—
Anion gap	29 ± 5	24 ± 1
AST (IU/L)	23 ± 6	45 ± 21
Bicarbonate (mmol/L)	—	—
BUN (mg/dl)	—	—
Calcium (mg/dl)	10.6 ± 0.1	11.1 ± 0.2
Chloride (mEq/L)	143 ± 2	144 ± 2
Cholesterol (mg/dl)	—	—
Creatine kinase (IU/L)	—	—
Creatinine (mg/dl)	0.5 ± 0	0.3 ± 0
Glucose (mg/dl)	100 ± 28	118 ± 10
LDH (IU/L)	221 ± 92	164 ± 54
Magnesium (mEq/L)	—	—
Osmolality (mOsm/kg)	348 ± 2	356 ± 2
Phosphorus (mg/dl)	10.0 ± 0.3	9.8 ± 0.2
Potassium (mEq/L)	3.9 ± 0.1	3.3 ± 0.2
Protein, total (g/dl)	3.8 ± 0.1	4.6 ± 0.1
Albumin (g/dl)	1.1 ± 0	1.3 ± 0
Globulin (g/dl)	—	—
A:G (ratio)	0.4 ± 0	0.4 ± 0
Sodium (mEq/L)	181 ± 4	174 ± 2
Total CO ₂ (mmol/L)	9.5 ± 1.0	10.7 ± 0.9
Urea Nitrogen (mg/dl)	—	—
Uric acid (mg/dl)	—	—

a Values listed are means except for the red pacu hematology and the shark data, which are medians. In some cases the data are not based on a large sample size. These values are only meant to be guidelines. Age of fish, time of year, and water temperature may all affect “normal” clinical pathologic data.

1.1 APPENDIX 2 Literature cited—fish.

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Amphibians

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Kevin Wright, DVM

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TABLE 5 Antimicrobial agents used in amphibians.^{a,b}

Agent	Dosage	Species/Comments
Amikacin	5 mg/kg SC, IM, ICe q24–48h ⁴⁷ 5 mg/kg IM q36h ¹⁷	Most species; may be used in combination with piperacillin ⁴⁷ Bullfrogs/PD
Carbenicillin	100 mg/kg SC, IM q72h ⁵ 200 mg/kg SC, IM, ICe q24h ²⁵	
Chloramphenicol	50 mg/kg SC, IM, ICe q12–24h ²⁵ 20 mg/L bath ²⁵	Change daily
Ciprofloxacin	10 mg/kg PO q24h ⁴⁷ 500–750 mg/75 L as 6–8 hr bath q24h ⁴⁷	May be used for large numbers of animals
Doxycycline (Vibramycin, Pfizer)	10–50 mg/kg PO q24h ²⁹ 5–10 mg/kg PO q24h ⁴⁴	African clawed frogs/chlamydiosis Chlamydiosis
Enrofloxacin	5–10 mg/kg PO, SC, IM q24h ^{17,47}	Most/PD (bullfrogs) ¹⁷ ; ICe and topical routes also used but not documented with PD ⁴⁷
Gentamicin	2–4 mg/kg IM q72h ×4 treatments ¹² 2.5 mg/kg IM q72h ³² 3 mg/kg IM q24h @ 22.2° C (72° F) ³³ 1.3 mg/L ×1 hr bath q24h ×7 days ¹² Topical to eyes ⁴²	Coldwater salamanders (e.g., <i>Necturus</i>)/PD; more frequent dosing may be needed if temperature >4° C (39.2° F) Leopard frogs/PD ³³ ; at higher temperatures, serum concentrations will be lower Bacterial dermatoses; can be toxic All/ocular infections; dilute to 2 mg/ml
Isoniazid	12.5 mg/L bath ²⁹	Mycobacteriosis
Metronidazole	10 mg/kg PO q24h ×5–10 days ²⁴ 12 mg/kg topically q24h × 5–10 days ⁴⁷ 50 mg/kg PO q24h ×3 days ⁴⁷ 60 mg/kg topically q24h ×3 days ⁴⁷ 10 mg/kg IV q24h ×2 days ⁴⁷ 50 mg/L ×24 hr bath ⁴⁷	For chronic diarrhea ²⁴ For chronic diarrhea ⁴⁷ Anaerobic infections Anaerobic infections Anaerobic infections Anaerobic infections
Neomycin, polymyxin (Neosporin, Pfizer)	Apply to wound topically q24h ¹⁰	Microsporidian infections ¹⁰
Nifurpirinol (Furanace, Dainippon)	250 mg/38 L ×1 hr bath q24h ¹²	
Nitrofurazone	10–20 mg/L ×24 hr bath ⁵	Change daily
Oxytetracycline	25 mg/kg SC, IM q24h ²⁵ 50 mg/kg PO q12–24h ²⁵ 50–100 mg/kg IM q48h ¹⁷ 100 mg/L ×1 hr bath ⁴⁷ 1 g/kg feed ×7 days ²⁵	Most species Most species Bullfrogs/PD ¹⁷ ; especially useful in cases of chlamydiosis (use up to 30 days) ⁴⁷ Most species
Piperacillin	100 mg/kg SC, IM q24h ⁴⁷	Anaerobes; may be used in combination with amikacin ⁴⁷
Rifampin	25 mg/L ×24 hr bath ⁹	Potentially effective for mycobacteriosis
Silver sulfadiazine (Silvadine Cream 1%, Marion)	Topical q24h ⁴⁵	Antibiotic cream

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Sulfadiazine	132 mg/kg PO q24h ²⁵	
Sulfamethazine	1 g/L bath to effect ²⁵	Change daily
Tetracycline	50 mg/kg PO q12h ⁵ 150 mg/kg PO q24h ×5–7 days ⁴⁰ 167 mg/kg (5 mg/30 g) PO q12h ×7 days ¹²	
Trimethoprim/sulfadiazine	15–20 mg/kg IM q48h ¹⁹	
Trimethoprim/sulfamethoxazole	15 mg/kg PO q24h ⁴⁷ 20 µg/ml and 80 µg/ml in 0.5% or 0.15% salt solution ×24 hr bath	Chronic diarrhea Bacterial dermatosepticemia; make fresh bath daily ²⁰
Trimethoprim/sulfa	3 mg/kg PO, SC, IM q24h ⁵	Unspecified sulfa
a Water baths containing antibiotics or topical applications may not provide as consistent distribution as parenteral administration.		
b SC can be administered in dorsal lymph sac of anurans. ⁶		

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TABLE 6 Antifungal agents used in amphibians.

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Agent	Dosage	Species/Comments
Amphotericin-B	1 mg/kg ICe q24h ⁴⁷	Internal mycoses
Benzalkonium chloride	2 mg/L ×1 hr bath q24h ²⁵ 1:4,000,000 bath ²⁵ 0.25 mg/L ×72 hr bath ⁵	Saprolegniasis Saprolegniasis; change water 3×/wk
Fluconazole	60 mg/kg PO q24h ⁴⁷	
Itraconazole	0.01% in 0.6% salt solution as 5 min bath q24h ×11 days ²³ 10 mg/kg PO q24h ⁴⁷	Topical route best choice to treat chytridiomycosis ²³
Ketoconazole	10 mg/kg PO q24h ²⁵ 10–20 mg/kg PO q24h ⁴⁷ Topical cream ⁷	Topical route best choice to treat chytridiomycosis ⁴⁶
Malachite green	0.15–0.20 mg/L ×1 hr bath q24h ¹²	Cutaneous mycoses; caution: mutagenic, teratogenic; potentially toxic
Mercurochrome	4 mg/L ×1 hr bath q24h ⁴¹	Saprolegniasis
Methylene blue	2–4 mg/L bath to effect ⁵ 4 mg/L ×1 hr bath q24h ⁴¹	Tadpoles/reduces mortality in newly hatched tadpoles Saprolegniasis
Miconazole	5 mg/kg ICe q24h ×14–28 days ⁴³ Topical cream ⁴⁷	Systemic mycoses Topical route best choice for chytridiomycosis; solutions containing alcohol may cause irritation
Nystatin 1% cream	Topical ⁴⁶	Cutaneous mycoses ⁴⁶
Potassium permanganate	1:5000 water ×5 min bath q24h ³	Cutaneous mycoses
Sodium chlorite (NaOCl ₂)	20 mg/L as 6–8 hr bath ⁴⁵	Cutaneous mycoses
Tolnaftate (Tinavet Cream 1%, Schering)	Topical ¹²	Cutaneous mycoses

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TABLE 7 Antiparasitic agents used in amphibians.^a

Agent	Dosage	Species/Comments
Acriflavin	0.025% bath ×5 days ²⁵	Protozoa
	500 mg/L ×30 min bath ³⁹	Protozoa
Benzalkonium chloride	2 mg/L ×1 hr bath q24h to effect ³⁹	Protozoa
Copper sulfate	0.1 mg/L as a continuous bath to effect ⁴⁷	Some protozoa; copper may be toxic to some amphibians
	500 mg/L ×2 min bath q24h to effect ²⁵	
Distilled water	3 hr bath ²⁵	Protozoa
Fenbendazole	—	Fenbendazole combinations follow
	30–50 mg/kg PO ⁶	Gastrointestinal nematodes
	50 mg/kg PO q24h ×3–5 days, repeat in 14–21 days ⁴⁷	Resistant nematode infections
	50–100 mg/kg PO, ²⁴ repeat in 2–3 wk prn	Most species/gastrointestinal nematodes
Fenbendazole (F)/ivermectin (I)	100 mg/kg PO, ³⁶ repeat in 14 days	Gastrointestinal nematodes
	(F) 100 mg/kg PO on day 1, then (I) 0.2 mg/kg PO on days 2, 11 ³⁶	
Fenbendazole (F)/metronidazole (M)	(F) 100 mg/kg PO, repeat in 10–14 days +(M) 10 mg/kg PO q24h for 5 days ³⁶	Concurrent gastrointestinal nematodes and protozoa
Formalin (10%)	—	Do not use if skin is ulcerated
	1.5 mL/L ×10 min bath q48h to effect ⁷	Protozoans; may be toxic in some species
	0.5% ×10 min bath once ²⁵	Monogenic trematodes; may be toxic to some amphibian species
Ivermectin	0.2–0.4 mg/kg PO, SC, repeat q14d prn ⁶	Nematodes, including lungworms; mites
	2 mg/kg topically, repeat in 2–3 wk ¹⁶	Especially useful for small specimens ⁴⁷ and <i>Rana</i> spp. ¹⁶
	10 mg/L as 60 min bath, repeat q14d prn ⁴⁷	Best route for treating mites ⁴⁷
Levamisole	—	May cause paralysis in some species at suggested dosages ⁴⁷
	10 mg/kg topically, ⁴⁷ IM, ⁵ ICe, ⁴⁵ repeat in 2 wk	Nematodes, including lungworms
	12 mg/L bath ×4 days ¹¹	African clawed frogs/cutaneous nematodes; use ≥4.2 L of tank water/frog
	100–300 mg/L ×24 hr bath, repeat in 1–2 wk ⁴⁷	Nematodes, including subcutaneous nematodes in aquatic amphibians; water-soluble form is available through aquaculture supply companies
	100 mg/L ×≥72 hr bath ⁴⁷	Resistant nematodes
Malachite green	0.15 mg/L ×1 hr bath q24h to effect ²⁵	Protozoa; caution: mutagenic, teratogenic; potentially toxic

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Metronidazole	—	See fenbendazole combinations Protozoa; for unfamiliar or sensitive species
	10 mg/kg PO q24h ×5–10 days ³⁶	Confirmed cases of amoebiasis and flagellate overload
	50 mg/kg PO q24h ×3–5 days ⁴⁷	Protozoa
	100 mg/kg PO q3d ⁷	Protozoa (e.g., <i>Entamoeba</i> , <i>Hexamita</i> , <i>Opalina</i>)
	100–150 mg/kg PO, repeat in 2–3 wk or prn ²⁵	Ciliates
	500 mg/100 g feed ×3–4 treatments ⁵	Fire-bellied toads (1.8 g/protozoa; rinse 1 hr after treatment; results in absorption of 23 mg/kg) BW of metronidazole
	0.05 ml of 1.008 mg/ml on dorsum q24h ×3 days ²¹	Aquatic amphibians/protozoa
	50 mg/L ×24 hr bath ²⁹	
Moxidectin	200 µg/kg SC q4mo ²⁸	Nematodes
Oxfendazole	5 mg/kg PO ⁴⁰	Gastrointestinal nematodes
Oxytetracycline	25 mg/kg SC, IM q24h ³⁹	Protozoa
	50 mg/kg PO q12h ³⁹	Protozoa
	1 g/kg feed ×7 days ³⁹	Protozoa
Paromomycin (Humatin, Parke Davis)	50–75 mg/kg PO q24h ⁴³	Gastrointestinal protozoa
Piperazine	50 mg/kg PO, repeat in 2 wk ¹²	Gastrointestinal nematodes
Potassium permanganate	7 mg/L ×5 min bath q24h to effect ²⁵	Ectoparasitic protozoa
Praziquantel	8–24 mg/kg topically, PO, SC, ICe, ⁴⁷ repeat q14d	Trematodes, cestodes
	10 mg/L ×3 hr bath, ⁴⁷ repeat q7–21d	Trematodes, cestodes
Salt (sodium chloride)	4–6 g/L bath ²⁵	Ectoparasitic protozoa
	6 g/L ×5–10 min bath q24h ×3–5 days ³⁹	Ectoparasitic protozoa
	25 g/L ×≤10 min bath ⁷	Ectoparasitic protozoa
Sulfadiazine	132 mg/kg q24h ³⁹	Coccidiosis
Sulfamethazine	1 g/L bath ³⁹	Coccidiosis; change daily to effect
Tetracycline	50 mg/kg PO q12h ³⁹	Protozoa
Thiabendazole	50–100 mg/kg PO, ¹² repeat in 2 wk prn	Gastrointestinal nematodes
	100 mg/L bath, repeat in 2 wk ⁴¹	Vermineous dermatitis
Trimethoprim/sulfa	3 mg/kg PO, SC, IM q24h ³⁹	Coccidiosis
a SC can be administered in dorsal lymph sac of anurans. ⁶		

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TABLE 8 Chemical restraint/anesthetic/analgesic agents used in amphibians.^a

Agent	Dosage	Species/Comments
Atipamezole (Antisedan, Pfizer)	Titrate to effect	Antagonist for dexmedetomidine ¹⁸
Benzocaine (Sigma Chemical)	— 50 mg/L bath to effect ⁶ 200–300 mg/L bath to effect ⁶ 200–500 mg/L bath ⁴	Anesthesia; not sold as fish anesthetic in the United States; available from chemical supply companies; do not use topical anesthetic products marketed for mammals; prepare stock solution in ethanol (poorly soluble in water); store in dark bottle at room temperature Larvae/dissolve in ethanol first Frogs, salamanders/dissolve in ethanol first Dissolve in acetone first
Buprenorphine (Buprenex, Reckitt & Colman)	38 mg/kg SC ¹⁸	Analgesia >4h; ED ₅₀ in leopard frog ¹⁸
Butorphanol (Torbugesic, Fort Dodge)	0.2–0.4 mg/kg IM ²⁷	Analgesia; dosage not determined but assumed to be similar to that in mammals
Clove oil (eugenol)	0.3 mL/L (~310–318 mg/L) ¹⁴ 0.45 mL/L (~473 mg/L) ²¹	Anesthesia; deep anesthesia after 15 min bath; caused reversible gastric prolapse in 50% of leopard frogs ¹⁴ Anesthesia; deep anesthesia induced in 80% of tiger salamanders
Codeine	53 mg/kg SC ¹⁸	Analgesia, >4 hr; ED ₅₀ in leopard frog ¹⁸
Dexmedetomidine (Precedex, Abbott)	40–120 mg/kg SC ¹⁸	Analgesia, >4 hr; ED ₅₀ in leopard frog ¹⁸
Diazepam	—	See ketamine combination
Fentanyl	0.5 mg/kg SC ¹⁸	Analgesia, >4 hr; ED ₅₀ in leopard frog ¹⁸
Halothane	4%–5% to effect ⁶	Terrestrial species/induction chamber
	Bubbled into water to effect ²⁹ 5% ²	Aquatic species Prolonged exposure for euthanasia
Isoflurane	— 3%–5% induction, 1%–2% maintenance ²⁷ 0.28 mL/100 mL bath ³⁰ Bubbled into water to effect ³⁰ Topical application of liquid isoflurane ³⁰ Topical mixture of isoflurane (3.0 mL), KY jelly (3.5 mL), and water (1.5 mL) ³⁰ 5% ²	Anesthesia; induction chamber; inhalant of choice Terrestrial species Induce in closed container Aquatic species <i>Bufo</i> spp. (0.015 mL/g BW), ³⁰ African clawed frog (0.007 mL/g BW) ³⁰ /induce in closed container; once induced, remove excess from animal <i>Bufo</i> spp. (0.035 mL/g BW), ³⁰ African clawed frog (0.025 mL/g BW) ³⁰ /induce in closed container; once induced, remove excess from animal Terrestrial species/euthanasia; induction chamber
Ketamine	— 50–150 mg/kg SC, IM ⁶	May have long induction and recovery times; does not provide good analgesia so may not be suited for major surgical procedures; other agents preferred; ketamine combination follows; see lidocaine Most species

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Ketamine (K)/diazepam (D)	(K) 20–40 mg/kg + (D) 0.2–0.4 mg/kg IM ²⁷	Variable results	
Lidocaine 1%-2%	Local infiltration ¹³	All/local anesthesia; with or without epinephrine; 2% lidocaine in combination with ketamine has been used for minor surgeries ²⁷ ; use with caution	
Meperidine	49 mg/kg SC ¹⁸	Analgesia >4 hr; ED ₅₀ in leopard frog ¹⁸	40
Methoxyflurane	0.5–1.0 ml in 1 L container (cotton soaked) ¹³	Induction in 2 min; surgical anesthesia maintained for about 30 min; recovery within 7 hr; not recommended because of potential of overdose ²⁷	41
Morphine	38–42 mg/kg SC ¹⁸	Analgesia, >4 hr	
Nalorphine	122 mg/kg SC ¹⁸	Analgesia, >4 hr	
Naloxone	10 mg/kg SC ¹⁸ ; titrate to effect	Antagonist for butorphanol, buprenorphine, codeine, fentanyl, meperidine, morphine	
Naltrexone	1 mg/kg SC ¹⁸ ; titrate to effect	Antagonist for butorphanol, buprenorphine, codeine, fentanyl, meperidine, morphine	
Pentobarbital sodium	40–50 mg/kg ICe ²⁷ 60 mg/kg ICe, ² IV	Frogs, toads/seldom used, other agents preferred; can also administer in dorsal lymph sac; anesthesia and recovery are prolonged Euthanasia; ICe is preferred route; can also be administered in lymph sacs in anurans	
Propofol	100–140 mg/kg topically ⁴⁶ 10–30 mg/kg ICe ³⁵ 60–100 mg/kg ICe ³⁵	Unpublished data; maroon-eyed tree frogs (<i>Agalychnis litodryas</i>); 15–20 min to max effect at 100 mg/kg dose, 10–15 min to max effect at 140 mg/kg ⁴⁶ ; sedation to deep anesthesia; remove and rinse when desired level achieved; recommended only for animals <50 g Pilot study in White's tree frogs; use the lower dosage for sedation or light anesthesia; induction within 30 min; recovery in 24 hr Euthanasia	
Tiletamine/zolazepam (Telazol, Fort Dodge)	10–20 mg/kg IM ²⁷	Results variable between species; recovery rapid; not suitable as single anesthetic agent for anurans ¹⁵	41

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Tricaine methanesulfonate (MS-222) (Finquel, Argent)	—	Anesthesia; buffer the acidity by adding sodium bicarbonate to buffer the solution to a pH of 7.0–7.1 ⁸ ; aerate water to prevent hypoxemia; remove from bath on induction or overdosing can easily occur; after bath, place terrestrial amphibians on moist towel or in very shallow water to recover ⁵ ; some species can be induced at much lower concentrations than listed here ⁴³ ; in some cases, anesthesia can be maintained by dripping a dilute solution of this drug (100–200 mg/L) over the skin or by covering animal with a paper towel moistened with the anesthetic ⁴³ Most gill-less adult species (unless very large)/induction Larvae/induction Tadpoles, newts/induction in 15–30 min Frogs, salamanders/induction in 15–30 min Toads/induction; takes 15–30 min Most species/may be irritating administered SC, IM (neutral solution is preferred) ⁸ Leopard frogs Bullfrogs Euthanasia; can be administered ICe or in lymph sacs
	1 g/L bath to effect ⁸ 100–200 mg/L bath to effect ³⁸ 200–500 mg/L bath to effect ⁶ 0.5–2.0 g/L bath to effect ⁶ 2–3 g/L bath to effect ⁴⁷ 50–200 mg/kg SC, IM, ICe ⁸ 100–200 mg/kg ICe ³¹ 100–400 mg/kg ICe ³¹ 10 g/L bath ²	
Yohimbine	Titrate to effect ¹⁸	Antagonist to dexmedetomidine
ED ₅₀ . Effective dose for 50% of the population.		

a SC can be administered in dorsal lymph sac in anurans.

TABLE 9 Hormones used in amphibians.^a

Agent	Dosage	Species/Comments
Gonadotropin-releasing hormone (GnRH)	0.1 mg/kg SC, IM, repeat prn ²⁵ 10 µg SC to female followed by additional 20 µg after 18 hr; 5 µg SC to male ³⁷	Induction of ovulation in those nonresponsive to PMSG or hCG; administer to females 8–12 hr before males Ovulation and spermiation in tomato frog (<i>Dyscophus guineti</i>)
Human chorionic gonadotropin (hCG)	50–100 ⁶ to 300 ²⁵ IU SC, IM 250–400 IU SC, IM ⁶	For mating or release of sperm in males; follow with GnRH in 8–24 hr African clawed frogs, axolotls, etc./induction of ovulation; may be used with PMSG and/or progesterone
Luteinizing hormone-releasing hormone	10 µg in 0.05 ml of 40% DMSO applied to ventral drink patch ²⁶ 5 µg ICe per salamander	Induced spermiation in 70% of male <i>Bufo americanus</i> or <i>B. valliceps</i> ²⁶ Induced oviposition in 94% of <i>Desmognathus ochrophaeus</i> ³⁴
Pregnant mare serum gonadotropin (PMSG)	50–200 IU SC, IM ⁶	African clawed frogs, axolotls, etc./induction of ovulation; administer 600 IU hCG IM, SC 72 hr later ²⁵
Progesterone	1–5 mg SC, IM ⁶	African clawed frogs, axolotls, etc./used in addition to PMSG or hCG for induction of ovulation

a SC can be administered into the dorsal lymph sac of anurans.

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TABLE 10 Miscellaneous agents used in amphibians.^a

Agent	Dosage	Species/Comments
Amphibian Ringer's solution (ARS)	6.6 g NaCl, 0.15 g KCl, 0.15 g CaCl ₂ , and 0.2 g NaHCO ₃ in 1 L water ^{7,47}	For treating hydrocoelom and subcutaneous edema; place animal in shallow ARS bath until stabilized (≈24 hr or more); replace with fresh solution daily; may need to wean animal off ARS by placing it in gradually more dilute solutions ⁴⁷ ; hypertonic solution created by using 800–950 ml water instead of 1 L and may be more effective for some cases of hydrocoelom ⁴⁷
Atropine	0.1 mg SC, IM prn	Organophosphate toxicosis ⁴⁷
Calcium glubionate	1 ml/kg PO q24h	Nutritional secondary hyperparathyroidism ⁴⁷
Calcium gluconate	100–200 mg/kg SC ⁴⁷ 2.3% continuous bath (with 47 2–3 IU/ml vitamin D ₃)	Hypocalcemic tetany ⁴⁷ Nutritional secondary hyperparathyroidism ⁴⁷
Cyanoacrylate surgical adhesive (Vet Bond, 3M)	Topical on wounds ⁷	Produces a seal for aquatic and semiaquatic species
Dexamethasone	1.5 mg/kg SC, IM ⁴²	Vascularizing keratitis; same dose IM or IV for shock
Dextrose 5% solution	Bath	For treating hydrocoelom and subcutaneous edema ⁴⁶ ; place animal in shallow bath until stabilized (≈24 hr or more); replace with fresh solution daily; may need to wean animal off dextrose by placing it in gradually more dilute solutions; 7.5%–10% solutions may be more effective for some cases of hydrocoelom
Feline Clinical Care Liquid (Pet-Ag)	1–2 ml/50 g PO q24h ⁴⁶ 3–6 ml/50 g PO q72h ⁴⁶	Dosage is approximate; may be more appropriate to offer larger volume less frequently for easily stressed animals
Flunixin meglumine	1 mg/kg SC, IM q24h ⁴⁷	Analgesia; adjunct treatment for septicemia
Hill's Feline A/D (Hill's)	PO ⁷	Nutritional support; mix 1:1 with water; generally gavaged
Laxative (Laxatone, Evsco)	PO ⁷	Laxative, especially for intestinal foreign bodies
Methylene blue	2 mg/ml bath to effect ⁴⁷	Nitrite and nitrate toxicoses
Orabase (Colgate)	Topical on wounds ⁷	Protective water-resistant ointment; antibiotics can be incorporated into the ointment ⁷ ; do not use preparation containing local anesthetic such as benzocaine ⁴⁶
Oxygen	100% for up to 24 hr ⁴⁷	Adjunct treatment for septicemia
Prednisolone sodium succinate	5–10 mg/kg IM, IV ⁴⁷	Shock
Sodium thiosulfate	1% solution as continuous bath to effect ⁴⁷	Halogen toxicoses
Vitamin B ₁	25 mg/kg feed fish ¹⁹	Deficiency resulting from thiaminase-containing fish
Vitamin D ₃	2–3 IU/ml continuous bath (with 2.3% calcium gluconate) ⁴⁷ 100–400 IU/kg PO q24h ⁴⁷	Nutritional secondary hyperparathyroidism
Vitamin E (alpha-tocopherol)	200 IU/kg feed ²⁵ 1 mg/kg IM, PO q7d ⁴⁷	Steatitis
Waltham Feline Concentration (Waltham)	PO ⁷	Nutritional support; mix 120 ml with 40–80 ml water; generally gavaged

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a SC can be administered into the dorsal lymph sac of anurans.

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APPENDIX 3 Physiologic and hematologic values of amphibians. ^{a,1,6}

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Measurement	Leopard Frog (<i>Rana pipiens</i>)		American Bullfrog (<i>Rana</i> <i>catesbeiana</i>)	Grass Frog (<i>Rana</i> <i>temporaria</i>)	Edible Frog (<i>Rana</i> <i>esculenta</i>)	Cuban Tree Frog (<i>Hyla</i> <i>septentrionalis</i>)	African Clawed Frog (<i>Xenopus</i> <i>laevis</i>)	Mudpuppy (<i>Necturus</i> <i>maculatus</i>)	Tiger Salamander (<i>Ambystoma</i> <i>tigrinum</i>)
	Male	Female							
BW (g)	25–42	25–46	225–306	—	—	28–35	—	—	35
Blood volume (ml/100 g BW)	—	—	3.1–3.6	—	—	7.2–7.8	—	—	—
Hematology									
PCV (%)	19–52	16–51	39–42	—	—	20–24	—	21	40
RBC ($10^3/\mu\text{l}$)	227–767	174–701	450	461	308	—	566	20	1657
Hb (g/dl)	3.8–14.6	2.7–14.0	9.3–9.7	14.34	9.7	5.6–6.8	14.9	4.6	9.4
MCV (fl)	722–916	730–916	—	—	—	—	—	10,070	—
MCH (pg)	182–221	182–238	—	—	—	—	—	2160	—
MCHC (g/dl)	22.7–26.8	19.9–27.7	21.1–25.9	—	—	25–31	—	22	—
WBC ($10^3/\mu\text{l}$)	3.1–22.2	2.8–25.9	—	14.4	6.1	—	8.2	—	4.6
Early stages (%)	—	—	—	1.5	1.0	—	0.7	—	—
Neutrophils (%)	—	—	—	6.5 \pm 1.0	8.8 \pm 2.1	—	8.0 \pm 1.1	—	—
Lymphocytes (%)	—	—	—	68.5 \pm 2.9	52.0 \pm 3.3	—	65.3 \pm 2.7	—	—
Monocytes (%)	—	—	—	0.8	1.3	—	0.5	—	—
Eosinophils (%)	—	—	—	14.5 \pm 2.9	19.4 \pm 1.3	—	?	—	—
Basophils (%)	—	—	—	24.2 \pm 2.2	16.6 \pm 1.3	—	8.5 \pm 1.4	—	—
Plasmocytes (%)	—	—	—	0.4	1.0	—	0.2	—	—
Thrombocytes ($10^3/\mu\text{l}$)	—	—	—	20.8	16.3	—	17.1	—	—

a Hematology is presently of limited diagnostic value because of the lack of normal data and the wide variation in hematologic and biochemical values according to sex, season, and state of hydration.

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APPENDIX 4 Differential diagnoses by predominant sign of amphibian.^a

Sign	Common Causes	Suggested Diagnostics ^b
Changes in skin color	Infectious agents: virus, bacteria, mycobacteria nodules, saprolegniasis, chromoblasto-mycosis, other mycoses, protozoa, myxosporeans, microsporidia, helminths (<i>Capillarioides xenopi</i>), leeches, fly larvae, other arthropods, fish lice, mollusks Noninfectious causes: toxicosis, hypothermia, hyperthermia, dehydration, dessication, burn, frostbite, trauma, neoplasia, nutritional secondary hyperparathyroidism, xanthomatosis/hyperlipidosis, drug reaction	Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); skin and blood culture; fecal parasite exams; plasma cholesterol and triglycerides; radiograph for skeletal density; plasma calcium and phosphorus; CBC and other plasma biochemistries
Changes in skin texture	Infectious agents: virus, bacteria, mycobacteria, mycoses, protozoa, myxosporeans, microsporidia, helminths, fly larvae, leeches, mites, ticks, fish lice, other arthropods, mollusks Noninfectious causes: toxicosis, hypothermia, hyperthermia, dehydration, dessication, stress, trauma (especially rostral abrasion), neoplasia, normal (e.g., dorsal crests in European newts, egg brood patch of Surinam toad, nuptial pads in male anurans)	Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); skin and blood culture; fecal parasite exams; CBC and plasma biochemistries
Excess mucus production	Infectious agents: virus, bacteria, mycoses, protozoa, helminths, arthropods, mollusks Noninfectious causes: toxicosis (ammonia, nitrite, chlorine, chloramine, salt, nicotine), poor water quality (pH, hardness, supersaturation), stress (cagemate, escape behavior, inappropriate soil pH or composition), hyperthermia, trauma	Husbandry review (diet, water quality tests, soil pH tests, temperature); skin scrapes (wet mount and stained); skin and blood culture; fecal parasite exams; CBC and plasma biochemistries
Fluctuant mass	Infectious agents: bacterial abscess, mycobacteria (rare), mycoses (rare), protozoal cyst, myxosporeans, helminths (e.g., immature trematodes and cestodes), subcutaneous leeches, fly larvae, mites, pentastomes Noninfectious causes: lymphatic blockage (e.g., gout, xanthomatosis, toxicosis, trauma), fluid overload, thermal injury, hypocalcemia, neoplasia, normal (e.g., active marsupium of <i>Gastrotheca</i> spp. females, water sacs of <i>Cycloderma rana</i> , distended lymphatic sacs of <i>Ceratophrys</i> spp.)	Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); aspirate (wet mount, stained, culture); fecal parasite exams; plasma uric acid, cholesterol and triglycerides; radiograph for skeletal density; plasma calcium and phosphorus; skin and blood culture; CBC and other plasma chemistries
Corneal opacity	Infectious agents: bacteria, mycoses, nematodes Noninfectious causes: scar, corneal lipidosis/xanthomatosis, trauma, chemical irritation, toxicosis, neoplasia	Husbandry review; slit lamp ophthalmic exam; culture and sensitivity; plasma cholesterol and triglycerides
Sudden death	Infectious agents: iridovirus, bacteria, chlamydiosis, chytridiomycosis Noninfectious causes: toxicosis (e.g., ammonia, household pesticides, chlorine), electrocution, hypothermia, hyperthermia, trauma, gastric overload/impaction, stress, drowning, neoplasia	Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); necropsy of dead specimens; physical exam of cagemates (include CBC, plasma biochemistries, blood culture, fecal parasite exams); consider euthanasia and necropsy of one or more cagemates

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Weight loss	<p>Infectious agents: chromomycosis, mycobacteriosis, coccidiosis, flagellate or ciliate overgrowth, helminths</p> <p>Noninfectious causes: heavy metal toxicosis (e.g., copper), chemical irritation (e.g., ammonia, chlorine, salt, pH), stress from inappropriate husbandry (e.g., environmental temperature too high, cagemate aggression), ocular disease with vision impairment, xanthomatosis</p>	Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); fecal parasite exams; CBC; skin and blood culture; plasma calcium, phosphorus, cholesterol, and triglycerides; radiograph for skeletal density; other plasma biochemistries	48
Anorexia, inappetence	<p>Infectious agents: iridovirus, Lucke's herpesvirus, other virus, bacteria, mycobacteria, chytridiomycosis, chromoblastomycosis, mucormycosis, protozoa, myxosporean, microsporidial, helminth, fly larvae, pentastomes, mites, ticks</p> <p>Noninfectious causes: inappropriate environment (e.g., substrate, temperature, illumination, photoperiod, humidity, lack of furnishings and hiding spots, inappropriate cagemates, too many cagemates or visible specimens in adjacent cages, activity in room), inappropriate feeding practices (e.g., wrong kind of food/prey, wrong size of food/prey, feeding at wrong times, too many prey items offered at one time), frequent handling or cage servicing, nutritional secondary hyperparathyroidism, hypocalcemia, toxicosis (e.g., copper, ammonia, chlorine), xanthomatosis, ocular disease with vision impairment, neoplasia, geriatric/senescence, normal (e.g., estivation or hibernation cues)</p>	Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); skin scrapes (wet mount and stained); skin and blood culture; fecal parasite exams; plasma cholesterol and triglycerides; radiograph for skeletal density; plasma calcium and phosphorus; CBC and other plasma biochemistries	49
Bloating	<p>Infectious agents: virus, bacteria, mycoses, mycobacteria, gastrointestinal nematodes</p> <p>Noninfectious causes: hypocalcemia (especially in hylid frogs), toxicosis, hypothermia, decomposition of ingesta (e.g., gastric overload, low or high temperatures), pneumocoelom (e.g., ruptured lung or trachea), gas supersaturation</p>	Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); fecal parasite exams; plasma calcium and phosphorus; radiograph; aspirate (wet mount, stained, culture); plasma biochemical analysis; ultrasonography; radiograph; skin and blood culture; CBC	49
Hydrocoelom	<p>Infectious agents: virus, bacteria, mycoses, mycobacteria, verminous granulomata, filarids, other helminths</p> <p>Noninfectious causes: toxicosis (e.g., heavy metal, chlorine, ammonia, insecticide, distilled or reverse osmosis water), hepatic failure, renal failure, hypocalcemia, xanthomatosis, gout, neoplasia (especially ovarian, hepatic or renal), failure to oviposit, normal (e.g., ovulation)</p>	Biology review of species in question; husbandry review (diet, water quality tests, soil pH, temperature); aspirate (wet mount, stained, culture); fecal parasite exams; plasma biochemical analysis; ultrasonography; radiograph; skin and blood culture; CBC	50
Lameness	<p>Infectious agents: virus, bacteria, mycobacteria, mycoses, protozoa, myxosporeans, microsporidia, helminths, fly larvae, pentastomes, mites</p> <p>Noninfectious causes: nutritional secondary hyperparathyroidism, trauma, malnutrition (e.g., hypovitaminosis B), thiaminosis, hypervitaminosis D, gout, xanthomatosis/hyperlipidosis, toxicosis (especially insecticides), neoplasia, drug reaction</p>	Husbandry review (diet, water quality tests, soil pH, temperature); radiograph; plasma calcium and phosphorus; plasma cholesterol and triglycerides; fecal parasite exams; CBC and other plasma chemistries	

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Spindly leg	<p>Infectious agents: iridovirus, larval cestodes or trematodes, subcutaneous nematodes</p> <p>Noninfectious causes: nutritional secondary hyperparathyroidism, malnutrition (e.g., hypovitaminosis B, protein deficiency, iodine deficiency, trace mineral deficiency, diet of parents, outdated food or vitamin supplements), toxicosis (ammonia, chlorine, nitrites), water quality (pH, hardness, temperature), crowding, poor illumination, trauma, genetic, hybridization</p>	<p>Biology review of species in question; husbandry review (water quality tests, temperature); diet (inspect actual food items and supplements in original containers); necropsy of dead specimens; physical exam of cagemates and parents; consider euthanasia and complete necropsy of one or more cagemates</p>
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- a This is based on the author's (K. W.) clinical impressions of the most common underlying etiologies for gross symptomology. A patient's differential list should be a comprehensive review of all potential etiologies regardless of likelihood.
- b Suggested diagnostics are presented in prioritized order.

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2.1 APPENDIX 5 Literature cited—amphibians.

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 Reptiles

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Geraldine Diethelm, VetMed

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TABLE 11 Antimicrobial agents used in reptiles.^{a,b}

Agent	Dosage	Species/Comments
Amikacin	—	Potentially nephrotoxic; maintain hydration; frequently used with a penicillin or cephalosporin
	5 mg/kg IM, then 2.5 mg/kg q72h ¹⁷⁰	Snakes/PD (gopher snakes); house at high end of optimum temperature range during treatment; use 1 mg/kg for blood pythons and 2 mg/kg for black-headed and rock pythons ¹⁸⁴
	3 mg/kg q72h SC, IM ¹³⁴	Pythons/PD (ball pythons)
	5 mg/kg IM, then 2.5 mg/kg q72h ^{8,78}	Lizards
	5 mg/kg IM q24h ⁸	Lizards
	5 mg/kg IM q48h ⁴⁰	Chelonians/PD (gopher tortoises)
	5 mg/kg IM, then 2.5 mg/kg q72h ¹⁷⁶	Chelonians
	2.5–3.0 mg/kg IM q72h ×5 treatments ²⁵²	Sea turtles
	2.25 mg/kg IM q72h ¹²⁴	Crocodylians/PD (alligators)
	50 mg/10 ml saline ×30 min nebulization q12h ¹⁹⁰	Most species/pneumonia; aminophylline at 25 mg/9 ml of sterile saline in nebulizer before antibiotics for bronchodilation ²⁰⁹ ; addition of hyaluronidase (Wydase) to nebulization solution (100–150 U/100 ml) aids in breakdown of proteinaceous debris ¹⁵⁶
	50–75 mg/10 ml saline ×30 min nebulization q12h ¹⁵⁶	
	2.5 mg/7.5 ml DMSO q12–24h topical ×21–28 days ²³⁶	For deep local penetration; abscesses involving bone
Amoxicillin	10 mg/kg IM q24h ²⁴⁶	Use with an aminoglycoside
	22 mg/kg PO q12–24h ⁸⁴	Use with an aminoglycoside
Ampicillin	—	May use with an aminoglycoside
	3–6 mg/kg PO, SC, IM q12–24h ^{82,84}	Most species
	10 mg/kg SC, IM q12h ¹³¹ or 20 mg/kg SC, IM q24h ^{23,236}	Most species, including chameleons
	6 mg/kg IM q12h ¹²⁶	Chelonians/ulcerative shell disease
	20 mg/kg IM q24h ^{176,199}	Chelonians
	50 mg/kg IM q12h ^{119,235}	Tortoises/preliminary study
Azithromycin	10 mg/kg PO q2–7d ⁵⁰	Ball pythons/PD; only single dose study done; may cause nonregenerative anemia; <i>Mycoplasma</i> , <i>Cryptosporidium</i> , <i>Giardia</i> , and other susceptible organisms; location dictates dosage frequency: skin, q3d; respiratory tract, q5d; liver/kidneys, q7d
Carbenicillin	400 mg/kg IM q24h ¹⁵²	Snakes/PD
	200 mg/kg IM q24h ¹¹¹	Carpet pythons
	400 mg/kg SC, IM q24h ⁸	Lizards/may use with an aminoglycoside (administer at different time of day)
	400 mg/kg IM q48h ¹⁵³	Chelonians/PD (<i>Testudo</i> spp.)
	200–400 mg/kg IM q48h ^{176,199}	Chelonians/may use with an aminoglycoside; may cause skin sloughing in desert tortoises

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Cefotaxime	20–40 mg/kg IM q24h ^{84,199} 100 mg/10 ml saline ×30 min nebulization q12h ¹⁹⁰	May use with an aminoglycoside Most species/pneumonia; addition of hyaluronidase (Wydase) to nebulization solution (100–150 U/100 ml) aids in breakdown of proteinaceous debris ¹⁵⁶	
Ceftazidime (Taxidime, Lilly)	20 mg/kg SC, IM, IV q72h ^{81,22,151} 20 mg/kg IM, IV q24h ²⁴⁴	Most species/PD (snakes); especially effective against gram-negative bacteria (e.g., <i>Pseudomonas</i>); q24–48h in chameleons ²³⁹ Sea turtles	
Ceftiofur	2.2 mg/kg IM q48h ²⁴⁶ 5 mg/kg SC, IM q24h ²¹ 2.2 mg/kg IM q24h ²⁴⁶ 4 mg/kg IM q24h ⁸⁴	Snakes Lizards (green iguanas) Turtles Tortoises/respiratory infection	56
Cefuroxime (Zinacef, Glaxo Wellcome)	50 mg/kg IM q48h ³ 100 mg/kg IM q24h ^{66,84}	Most species Most species, including snakes/may use with an aminoglycoside	57
Cephalexin	20–40 mg/kg PO q12h ²⁴⁶	Most species	
Cephaloridine	10 mg/kg SC, IM q12h ⁸²	Most species	
Cephalothin	20–40 mg/kg IM q12h ⁸⁴	Most species	
Cephazolin	20 mg/kg SC, IM q24h ¹⁶⁹	Most species/burns	
Cephoperazone (Cefobid, Roerig)	100 mg/kg IM q96h ²³³ 125 mg/kg IM q24h ²³³	Snakes/PD (ground snakes) Lizards/PD (tegus)	
Chloramphenicol	— 40 mg/kg PO, SC, IM q24h, or 20 mg/kg PO, SC, IM q12h ^{119,126,129,179,199} 40 mg/kg SC q24h ³⁸ 50 mg/kg SC q12–72h ^{47,120,123} Topical ophthalmic ointment ¹²⁶	Most species/public health concern; may result in permanent pigmentation change in chameleons when given IM; may cause bone marrow suppression in water snakes ¹¹⁹ ; because it is bacteriostatic, it has limited usefulness in reptiles Most species/20 mg/kg may be given q24h in larger crocodilians Snakes/PD (gopher snakes) Snakes/PD; q12h in indigo, rat, and king snakes; q24h in boids, moccasin snakes; q48h in rattlesnakes; q72h in red-bellied water snakes Most species	
Chlorhexidine (Nolvasan 2%, Fort Dodge)	Topical 0.05% aqueous solution or ointment ^{10,41} 1:30 aqueous solution ²⁸ 1:10 aqueous solution, irrigation q24h ¹⁷⁹ 1:10 dilution, soak 1 hr q12h ¹²⁶	All species/topical disinfection; infectious stomatitis Most species/topical disinfection; infectious stomatitis; middle ear infection flush in box turtles Lizards/periodontal disease (irrigation of gingival pockets) Lizards, snakes/in conjunction with antibiotic therapy; soak at 27° C–30° C (81° F–86° F)	
Chlortetracycline	200 mg/kg PO q24h ³	Most species	57
Ciprofloxacin	10 mg/kg PO q48h ⁶⁶ 11 mg/kg PO q48–72h ¹⁴²	Most species Pythons/PD (reticulated pythons)	58

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Clarithromycin (Biaxin, Abbott)	15 mg/kg PO q48-72h ^{132,255}	Tortoises/PD (desert tortoises); upper respiratory tract disease (mycoplasmosis)
Clindamycin	2.5–5.0 mg/kg PO q12h ⁸² 5 mg/kg PO q24h ²⁴⁶	Most species/gram-positive bacteria and anaerobes Most species
Dihydrostreptomycin	5 mg/kg IM q12–24h ^{84,246}	Most species/maintain hydration
Doxycycline (Vibramycin, Pfizer)	5–10 mg/kg PO q24h ×10–45 days ^{3,84,129} 10 mg/kg PO q24h ²⁵⁸ 50 mg/kg IM, then 25 mg/kg q72h ^{119,134}	Most species/respiratory infection (e.g., mycoplasmosis); may use nystatin concurrently to prevent secondary yeast infections ¹⁸⁴ Tortoises Tortoises
Enrofloxacin (Baytril, Bayer)	5–10 mg/kg q24h PO, SC, IM, ICe ³ 6.6 mg/kg IM q24h or 11 mg/kg IM q48h ¹⁴² 10 mg/kg IM q48h ²⁶¹ 10 mg/kg IM, then 5 mg/kg q48h ²⁶¹ 5 mg/kg PO, IM q24h ¹⁷⁷ 10 mg/kg IM q5d ¹¹² 5 mg/kg IM q24–48h ^{22,205}	Most species/IM administration is painful and may result in tissue necrosis and sterile abscesses; may cause skin discoloration or tissue necrosis if given SC Pythons/PD (reticulated pythons); <i>Pseudomonas</i> Snakes/PD (Burmese pythons); <i>Pseudomonas</i> Snakes/PD (Burmese pythons) Lizards/PD (green iguanas); marked pharmacokinetic variability with PO administration may make IM more suitable in critically ill animals Monitors/PD (savannah monitors); preliminary data Chelonians and most other reptiles/PD (gopher tortoises); hyperexcitation, incoordination, diarrhea reported in a Galapagos tortoise ⁴³
	5 mg/kg IM q12–24h ²¹⁴ 5 mg/kg IM q48h ²⁵² 10 mg/kg IM q24h ²³⁵ 5 mg/kg IV q36h ¹⁰³ 1–3 ml (50 mg/250 ml sterile water) nasal flush/nostril q24–48h ¹²⁹ 11.4 mg/7.5 ml DMSO topical q12–24h ×21–28 days ²³⁶	Chelonians/PD (star tortoises); q12h for <i>Pseudomonas</i> and <i>Citrobacter</i> ; q24h for other bacteria Sea turtles Chelonians/PD (Hermann's tortoises) Crocodilians/PD (alligators); 5 mg/kg PO did not achieve minimum inhibitory values for susceptible organisms ¹⁰³ ; mycoplasmosis Upper respiratory infection; use until no discharge; use concurrently with parenteral antibiotics For deep local penetration; abscesses involving bone

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Gentamicin	—	Nephrotoxicity has been reported, especially in snakes; maintain hydration; commonly used with a penicillin or cephalosporin Snakes/PD (gopher snakes) 2.5 mg/kg IM q72h ^{38,39} 2.5–3.0 mg/kg IM, then 1.5 mg/kg q96h ¹⁰⁸ 3 mg/kg IM q>96h ¹¹ 5 mg/kg IM q72h ^{176,199} 6 mg/kg IM q72–96h ²¹³ 2–4 mg/kg IM q72h ¹²⁶ 1.75–2.25 mg/kg IM q72–96h ^{119,124} 10–20 mg/15 ml saline ×30 min nebulization q12h ^{94,156}	59
	50 mg/9 ml saline ×30 min nebulization q12h ²⁰⁹ 40 mg/1 ml DMSO/8 ml saline, nebulization ²⁵⁸ Topical ophthalmic ointment ¹²⁶ or drops	Most species/aminophylline at 25 mg/9 ml of sterile saline in nebulizer before antibiotics for bronchodilation Tortoises Most species/superficial ocular infection; lesions in oral cavity ¹⁶⁶	60
Gentamicin/betamethasone ophthalmic drops (Gentocin Durafilm, Schering-Plough)	1–2 drops to eye q12–24h ¹³²	Tortoises/upper respiratory infections; may also be given as a reverse nasal flush q48–72h or intranasal q12–24h	
Kanamycin	10–15 mg/kg IM, IV q24h (or in divided doses) ⁸²	Most species/avoid in cases of dehydration or renal or hepatic dysfunction; maintain hydration	
Lincomycin	5 mg/kg IM q12–24h ⁶⁶ 10 mg/kg PO q24h ⁶⁶	Most species/wound infection; potentially nephrotoxic; maintain hydration Most species	
Marbofloxacin	10 mg/kg PO q48h ⁵¹	Ball pythons/PD	
Metronidazole	20 mg/kg PO q24h ×≥7 days ¹²¹ 50 mg/kg PO q24h ×7–14 days ¹⁴² 20 mg/kg PO q48h ¹⁴⁸ 50 mg/kg PO q48h ²⁵ 20 mg/kg PO q24–48h ¹⁴⁹	Most species/anaerobes; dose range 12.5–40.0 mg/kg ⁸² Most species/may be administered concurrently with amikacin for broader spectrum; because of potential side effects at this dose, a lower dose may be prudent ¹⁴² Snakes/PD (yellow rat snakes) Corn snakes/PD Iguanas/PD; use q24h for resistant anaerobes	
Neomycin	10 mg/kg PO q24h ⁶⁶	Most species	
Oxytetracycline	6–10 mg/kg PO, IM, IV q24h ^{66,82} 5–10 mg/kg IM q24h ¹³²	Most species/may produce local inflammation at injection site Tortoises/upper respiratory tract infection (mycoplasmosis)	60
	10 mg/kg PO q24h ²⁰³ 10 mg/kg IM, IV q5d ¹⁰²	Alligators Crocodilians/PD (alligators); mycoplasmosis	61

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Penicillin, benzathine	10000 IU/kg IM q48–96h ⁸²	Most species/frequency depends on temperature; may use with an aminoglycoside	
Penicillin G	10000–20000 IU/kg SC, IM, IV, ICe q8–12h ⁸²	Most species/infrequently used	
Piperacillin (Pipracil, Lederle)	50–100 mg/kg IM q24h ⁸² 100–200 mg/kg IM q24–48h ^{131,236} 50 mg/kg IM, then 25 mg/kg q24h ²⁴⁶ 100 mg/kg IM q48h ¹⁰⁹ 100 mg/10 ml saline ×30 min nebulization q12h ^{156,190}	Most species/broad-spectrum bactericidal agent; maintain hydration; may use with an aminoglycoside Most species (including chameleons)/can be administered SC in most species Snakes Snakes/PD (blood pythons) Most species/pneumonia; addition of hyaluronidase (Wydase) to nebulization solution (100–150 U/100 ml) aids in breakdown of proteinaceous debris	
Polymyxin B, neomycin, bacitracin cream	Topical ²⁰³	All species	
Povidone-iodine solution (0.05%) or ointment	Topical ²⁰³	All species/can soak in 0.005% aqueous solution ≤1 hr q12–24h	
Silver sulfadiazine cream (Silvadene, Marion)	Topical q24–72h ^{167,203}	All species/broad-spectrum antibacterial for skin (e.g., wounds, burns) or oral cavity; dressing is generally not necessary	
Streptomycin	10 mg/kg IM q12–24h ⁸²	Potentially nephrotoxic; maintain hydration; avoid in cases of dehydration or renal or hepatic dysfunction	
Sulfadiazine	25 mg/kg PO q24h ²⁴⁶	Maintain hydration	
Sulfadimethoxine	90 mg/kg IM, then 45 mg/kg q24h ⁸²	Potentially nephrotoxic; maintain hydration	
Tetracycline	10 mg/kg PO q24h ¹²⁶	Most species/seldom used	61
Ticarcillin (Ticar, SmithKline-Beecham)	50–100 mg/kg IM q24h ⁸²	Most species/maintain hydration	62
Tobramycin (Nebcin, Lilly)	— 2.5 mg/kg IM q24–72h ^{3,84} 2.5 mg/kg IM q72h ²³⁹ 10 mg/kg IM q24h ⁶⁶	Potentially nephrotoxic; maintain hydration; potentiated by β-lactams Most species Chameleons/more frequent administrations have been reported ¹³¹ Chelonians/can be given q48h in tortoises	
Trimethoprim/sulfadiazine	— 15–25 mg/kg PO q24h ²⁴⁶ 20–30 mg/kg PO, SC, IM q24–48h ¹⁴² 30 mg/kg IM q24h ×2 days, then q48h ^{7,120,176}	Maintain hydration; parenteral form must be compounded Most species Most species Most species/can administer PO, SC	
Trimethoprim/sulfamethoxazole	10–30 mg/kg PO q24h ⁸²	Most species/maintain hydration	
Tylosin	5 mg/kg IM q24h ×10–60 days ^{84,126}	Most species/mycoplasmosis	
<p>a Because reptiles are ectothermic, pharmacokinetics of drugs are influenced by ambient temperature. Antimicrobial therapy should be conducted at the upper end of the patient's preferred optimum temperature zone.</p> <p>b See Appendix 105 for antimicrobial combination therapies, some of which are commonly used in reptiles.</p>			

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TABLE 12 Antiviral agents used in reptiles.

Agent	Dosage	Species/Comments
Acyclovir (Zovirax, Burroughs-Wellcome)	80 mg/kg PO q24h ×10 days ¹⁴²	Tortoises/antiviral (e.g., herpes virus dermatitis); nebulization may help ¹⁹⁶
	Topical (5% ointment) q12h ²¹⁹	Tortoises/antiviral (e.g., herpes virus dermatitis)

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TABLE 13 Antifungal agents used in reptiles.

Agent	Dosage	Species/Comments
Amphotericin-B	0.5–1.0 mg/kg IV, ICE q24–72h ×14–28 days ⁶⁶ 1.0 mg/kg IT q24h ×14–28 days ¹²⁸ 0.5 mg/kg IV q48–72h ⁸² 0.1 mg/kg intrapulmonary q24h ×28 days ¹⁰⁴ 5 mg/150 ml saline ×1 hr nebulization q12h ×7 days ¹¹⁸	Most species/aspergillosis Most species/respiratory infection; dilute with water or saline Most species/nephrotoxic; can use in combination with ketoconazole; administer slowly Greek tortoises/pneumonia Most species/pneumonia
Chlorhexidine (Nolvasan 2%, Fort Dodge)	20 ml/gal water bath ²⁵⁶	Lizards/dermatophytosis
Clotrimazole (Veltrim, Haver-Lockhart; Otomax, with gentamicin and betamethasone, Schering-Plough)	Topical ²¹⁹	Most species/dermatitis; may bathe q12h with dilute organic iodine before use
Fluconazole	5 mg/kg PO q24h ²⁵⁶ 21 mg/kg SC once, then 10 mg/kg SC 5 days later ^{90,173}	Lizards/dermatophytosis Loggerhead sea turtles/PD
Griseofulvin	20–40 mg/kg PO q72h ×5 treatments ²¹⁹	Most species/dermatitis; limited success
Itraconazole	5 mg/kg PO q24h ⁸³ 23.5 mg/kg PO q24h ⁹⁹ 5 mg/kg PO q24h or 15 mg/kg PO q72h ¹⁷⁴	Panther chameleons Lizards/PD (spiny lizards); after a 3-day treatment, a therapeutic plasma concentration persists for 6 days beyond peak concentration; treatment interval was not determined Kemp's Ridley sea turtles
Ketoconazole	— 15–30 mg/kg PO q24h ×14–28 days ⁸⁴	May use antibiotics concomitantly to prevent bacterial overgrowth; may use concurrently with thiabendazole Most species
	25 mg/kg PO q24h ×21 days ¹¹⁹ 15–30 mg/kg PO q24h ×14–28 days ^{176,200} 50 mg/kg PO q24h ×14–28 days ²⁴⁶	Snakes, turtles Chelonians/PD (gopher tortoises); systemic infection Crocodilians
Malachite green	0.15 mg/L water ×1 hr bath ×14 days ⁶⁶	Dermatitis
Miconazole (Monistat-Derm, Ortho)	Topical ²¹⁹	Most species/dermatitis; may bathe q12h with dilute organic iodine before use
Nystatin	100,000 IU/kg PO q24h ×10 days ¹¹⁸	Most species/enteric yeast infections; limited success
Thiabendazole	50 mg/kg PO q24h ×14 days ¹²⁶	Chelonians/pneumonia; dermatitis; may use concurrently with ketoconazole
Tolnaftate 1% cream (Tinactin, Schering-Plough)	Topical q12h prn ³	Most species/dermatitis; may bathe q12h with dilute organic iodine before use

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TABLE 14 Antiparasitic agents used in reptiles.

Agent	Dosage	Species/Comments
Albendazole	50 mg/kg PO ²⁴⁶	Most species/ascarids
Carbaryl powder (5%)	Topical q7d prn ⁸	Most species, primarily snakes/mites; apply sparingly; may rinse after 1–5 min; must treat environment concurrently; alternatively, dust empty cage lightly, place animal in cage for 24 hr, then bathe animal and wash cage
Chloroquine	125 mg/kg PO q48h ×3 treatments ²⁴⁶	Tortoises/hemoprotozoa
Dimetridazole (Emtryl, Rho ône-Poulenc, Canada)	100 mg/kg PO, repeat in 14 days, ¹²⁰ or 40 mg/kg PO q24h ×5–8 days ¹⁸¹ 40 mg/kg PO, repeat in 14 days ¹²⁰	Snakes (except milk and indigo)/amoebae, flagellates; not available in the United States Milk and indigo snakes/amoebae, flagellates
Emetine	0.5 mg/kg SC, IM q24h ×10 days ³	Most species/amoebae, trematodes; higher doses (2.5–5.0 mg/kg) have been reported ¹⁴³ ; avoid use in debilitated animals
Fenbendazole	— 25 mg/kg PO q7d for up to 4 treatments ¹⁴¹ 50–100 mg/kg PO, repeat q14d prn ^{8,118,120,175} 50 mg/kg PO q24h ×3–5 days ⁸⁶ 50 mg/kg PO q24h ×3 days every 7–10 days ¹⁴⁵ 50 mg/kg PO q24h ×3 days or 100 mg/kg PO q14–21d ²⁵⁸ 100 mg/kg PO q48h ×3 treatments; repeat the 3 treatments in 21 days ^{28,183,184}	Drug of choice for nematodes; may have an antiprotozoan effect ¹⁴⁰ ; can be given percloacally or use powdered form on food in tortoises ¹¹³ All species All species/use 25 mg/kg in ball pythons All species/in chameleons for flagellates, nematodes, and giardia ¹⁴⁵ Chameleons/nematodes Tortoises Turtles/lower dose (25 mg/kg) has also been recommended ¹³⁸
Fipronil (0.25%) (Frontline, Merial)	Spray or wipe on q7–10d ⁶⁹	Most species/mites, ticks; beware of reactions to alcohol carrier; use with caution; use in reptiles needs further evaluation ⁴¹

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Ivermectin	—	<p>Do not use in chelonians (may be toxic),²⁵⁰ crocodilians (may have narrow margin of safety),¹⁴⁰ indigo snakes, and skinks³⁴</p> <p>Snakes (except indigos), lizards (except skinks)³⁴/nematodes, mites; caution: colored animals may have skin discoloration at injection site; rarely, adverse effects have been observed in chameleons, possibly associated with breakdown of parasites⁸; do not use within 10 days of diazepam and tiletamine/zolazepam; can dilute with propylene glycol; narrower range of safety than fenbendazole; rare deaths and occasional nervous system signs, lethargy, or inappetence have been reported (especially in lizards)¹⁴⁰; used for pentastomids in monitor lizards (used with dexamethasone 0.2 mg/kg q2d)⁷⁹; surgical removal may be required⁷⁵</p> <p>Snakes (except indigos), lizards (except skinks)/mites; spray on skin and in cage; some wash cage out 15 min later, others let cage dry before replacing reptile; some recommend ivermectin spray for the animal and a pyrethroid or larval inhibitor for the environment¹³⁹</p>	67
Levamisole (Levasole 13.65%, Mallinckrodt)	<p>5–10 mg/kg SC, ICE, repeat in 14 days¹⁴² (5 mg/kg in chelonians¹⁷⁶; 10 mg/kg in lizards,⁸ snakes¹¹⁸)</p>	<p>Most species/nematodes (including lungworms); very narrow range of safety; main advantage is that it can be administered parenterally; avoid concurrent use with chloramphenicol; avoid use in debilitated animals; low dose may stimulate depressed immune system; can be used IM, but less effective</p>	67
Mebendazole	<p>10–20 mg/kg SC, IM, ICE¹²⁸</p> <p>20–100 mg/kg PO, repeat in 14 days⁶⁹</p>	<p>Most species, including turtles</p> <p>Most species/strongyles, ascarids</p>	68

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Metronidazole	—	Protozoan (e.g., flagellates, amoebae) overgrowth; may stimulate appetite; may cause seizures if overdosed ¹¹⁹ ; for small patients, injectable form can be administered PO; oral liquid is not available in the United States, but can be compounded	
	25–40 mg/kg PO on days 1, 3 or q24h for up to 7 days ¹⁴¹	Most species	
	40–125 mg/kg PO, repeat in 10–14 days ^{140,142}	Most species/q72h ×5–7 treatments for amoebae	
	100 mg/kg PO q3d ×14–28 days ¹⁰	Most species	
	100 mg/kg PO, repeat in 14 days ^{8,119–121}	Most species (except uracoan rattler, milk, tricolor king, and indigo snakes)	
	125–250 mg/kg PO, repeat in 14 days ^{82,199}	Most species/recommend using lower end of dose range	
	40 mg/kg PO, repeat in 14 days ¹²⁰	Uracoan rattler, milk, tricolor king, and indigo snakes	
	50 mg/kg PO q48h ²⁵	Corn snakes	
	40–60 mg/kg PO q7–14d ×2–3 treatments ²³⁹	Chameleons	
	50 mg/kg PO q24h ×2–5 days ¹⁴⁵	Chameleons/when accompanied by increased gastrointestinal symptoms	
	40–200 mg/kg PO, repeat in 14 days ¹⁸⁶	Geckos/ocular lesions (40 mg/kg) and subcutaneous lesions (200 mg/kg) caused by <i>Trichomonas</i>	
	50 mg/kg PO q24h ×3–5 days or 100 mg/kg PO q14–21d ²⁵⁹	Chelonians (tortoises)/use the lower dosage for severe cases	68
Milbemycin	0.25–0.5 mg/kg SC prn ²⁴	Chelonians/nematodes; parenteral form is not commercially available in the United States; fenbendazole preferred	69
	0.5–1.0 mg/kg PO prn ²⁴	Chelonians/nematodes; fenbendazole preferred	
Nitrofurazone	25.5 mg/kg PO ²⁵³	Most species/coccidia; seldom used	
Olive oil	Coat q7d ⁸	Most species, especially small, delicate lizards/mites; wash animal with mild soap (and rinse well) the next day; messy to use; environment must be treated	
Oxfendazole (Benzelmin, Fort Dodge)	68 mg/kg PO, repeat in 14–28 days prn ⁶⁹	Most species/nematodes	
Paromomycin (Humatin, Parke Davis)	35–100 mg/kg PO q24h ×≤28 days ^{82,118,254}	Most species/amoebae	
	100 mg/kg PO q24h ×7 days, then 2×/wk ×3 mo ⁵⁵	Snakes/cryptosporidia; reduced clinical signs and oocyte shedding; does not eliminate the organism	
	300–360 mg/kg PO q48h ×14 days ²⁰²	Lizards (gila monsters)/cryptosporidia	
	300–800 mg/kg PO q24h prn ⁴⁹	Geckos/cryptosporidia; reduced clinical signs; does not eliminate the organism	
Permethrin (10%) (Permectrin II, Boehringer Ingelheim; Proventamite, Pro Products)	Topical, repeat in 10 days ²⁶	Most species/mites; a pyrethroid; safer than pyrethrins; use with care; dilute to a 1% solution and apply lightly with spray bottle in a well-ventilated enclosure (with water bowl removed for 24 hr); blot off excess; administer in conjunction with environmental control; permethrin topically on tortoises; treatment of substrate after removal of lizards and snakes from environment ³⁷	
Piperazine	40–60 mg/kg PO, repeat in 14 days ³	Most species/nematodes	69
	50 mg/kg PO, repeat in 14 days ¹²⁶	Crocodilians	70

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Praziquantel (Droncit, Mobay)	8 mg/kg PO, SC, IM, repeat in 14 days ^{8,120,131} 5–10 mg/kg PO q14d ¹⁴⁵ 25 mg/kg PO q3h ×3 treatments ¹²⁵	Most species/cestodes, trematodes; doses >8 mg/kg have shown potential for treating pentastomids ¹⁴³ ; higher dosages have been administered PO ^{4,23} Chameleons/flukes may best be left untreated if not causing a problem ¹⁴⁵ Sea turtles/PD (loggerhead sea turtles)
Pyrantel pamoate (Nemex-2, Pfizer)	5 mg/kg PO, repeat in 14 days ⁸²	Most species/nematodes
Pyrethrin spray (0.09%)	Topical q7d ×2–3 treatments	Most species/use water-based sprays labeled for kittens and puppies; apply with cloth; can also spray cage, wash out after 30 min; use sparingly and with caution; pyrethroids are safer (see permethrin, resmethrin)
Quinacrine (Atabrine, Winthrop)	19–100 mg/kg PO q48h ×14–21 days ²⁵³	Most species/some hematozoa
Quinine sulfate	75 mg/kg PO q48h ×14–28 days ²⁵³	Most species/some hematozoa; toxic at >100 mg/kg q24h; ineffective against exoerythrocytic forms
Resmethrin spray or shampoo (Durakyl, DVM Pharmaceuticals)	Topical, ¹⁷² repeat prn q≥10d	Most species/mites; a pyrethroid; safer than pyrethrins; use with care; spray (0.35%) or shampoo entire animal, then rinse off immediately in running, tepid water; protect eyes (other than snakes) with 1 drop of mineral oil; lightly spray environment, wipe off in 5–10 min
Spiramycin (Spirasol, May and Baker)	160 mg/kg PO q24h ×10 days ^{54,55}	Snakes/cryptosporidia; may reduce clinical signs and oocyte shedding; does not eliminate the organism
Sulfadiazine, sulfamerazine	50 mg/kg PO q24h ×3 days, off 3 days, on 3 days ¹³⁷ 75 mg/kg PO, then 45 mg/kg q24h ×5 days ^{82,145,253} 25 mg/kg PO q24h ×21 days ^{8,126,253}	Most species/avoid in cases of dehydration or renal dysfunction Most species/coccidia Snakes, lizards/coccidia; avoid in cases of dehydration or renal dysfunction
Sulfadimethoxine (Albon, Roche)	— 50 mg/kg PO q24h ×3–5 days, then q2d prn ^{137,144} 90 mg/kg PO, IM, IV, then 45 mg/kg q24h ×5–7 days ^{84,118,253}	Coccidia; avoid in cases of dehydration or renal dysfunction Most species Most species
Sulfadimidine (33% solution)	1 oz/gal drinking water ×10 days ²⁵³ 0.3–0.6 ml/kg PO q24h ×10 days ²⁵³	Most species/coccidia Most species/coccidia; alternatively, 0.3–0.6 ml/kg, then 0.15–0.30 ml/kg q24h ×2–10 days
Sulfamethazine	50 mg/kg PO q24h ×3 days, off 3 days, on 3 days ¹³⁷ 75 mg/kg PO, IM, IV, then 40 mg/kg q24h ×5–7 days ^{3,84,118} 25 mg/kg PO, IM q24h ×7–21 days ^{3,253}	Most species/coccidia Most species/coccidia Snakes/coccidia
Sulfamethoxydiazine	80 mg/kg SC, IM, then 40 mg/kg q24h ×4 days ²⁵³	Most species/coccidia
Sulfaquinoxaline	75 mg/kg PO, then 40 mg/kg q24h ×5–7 days ¹¹⁸	Most species/coccidia
Thiabendazole	50–100 mg/kg PO, repeat in 14 days ^{82,120}	Most species/nematodes; fenbendazole preferred

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Trimethoprim/sulfa	30 mg/kg IM q24h ×2 days, then 15 mg/kg q48h	Most species/coccidia; may be administered SC ¹⁸⁴	71
	×5–14 days ²⁵³		
	30 mg/kg PO q24h ×7 days, or 15 mg/kg PO q12h	Most species/coccidia	
	×7 days ¹²⁹		
	30 mg/kg PO q24h ×2 days, then q48h ×21	Most species/coccidia	72
	days ^{8,253}		
	30–60 mg/kg PO q24h ×2 mo ³	Snakes/use in treatment of cryptosporidia is of questionable value; may be toxic at this dosage	
Vapona No-Pest Strip (Shell Chemical)	6 mm strip/10 ft ³ ×3–5 days; 2.5 cm ² in perforated plastic film container ×2–5 days ^{82,84}	Most species/mites; use with caution; prevent contact with animals (e.g., place strip above cage); avoid in cases of renal or hepatic dysfunction; remove water container; some recommend not to use continuously (expose 2–3 hr, 2–3×/wk for 3–4 wk) ¹³⁷ ; because of its toxicity and availability of safer alternatives, use is discouraged	72
Water	Bath ×30 min ¹⁶⁵	Snakes, lizards/mites; use lukewarm water; safe, but not very effective; does not kill mites on head	72

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TABLE 15 Chemical restraint/anesthetic/analgesic agents used in reptiles.

Agent	Dosage	Species/Comments
Acepromazine	0.05–0.25 mg/kg IM ¹²⁹	Most species/can be used as a preanesthetic with ketamine
	0.1–0.5 mg/kg IM ^{187,198}	Most species/preanesthetic; reduce by 50% if used with barbiturates
Alphaxalone/alphadolone (Saffan, Glaxcovet Labs)	6–9 mg/kg IV, or 9–15 mg/kg IM ¹⁵⁴	Most species/good muscle relaxation; variable results; drug requires more evaluation; may have violent recovery ¹³ ; do not use within 10 days of DMSO treatment; not available in the United States
	9 mg/kg IV, intracardiac ¹⁸⁷	Snakes/induction, 5 min; good muscle relaxation; variable results; minimal effect if administered IM
	15 mg/kg IM ¹⁸⁷	Lizards, chelonians/induction, 35–40 min; duration, 15–35 min; good muscle relaxation; variable results
	24 mg/kg ICe ⁸⁸	Chelonians (red-eared sliders)/surgical anesthesia with good relaxation
Atipamezole (Antisedan, Pfizer)	5×medetomidine dose IM, IV ^{80,232}	Medetomidine reversal; causes severe hypotension in gopher tortoises when given IV ⁶¹
Atropine	0.01–0.04 mg/kg SC, IM, ²⁷ IV, ⁸² ICe ²²⁷	Most species/preanesthetic; bradycardia; rarely indicated; generally use only in profound or prolonged bradycardia ²²⁷ ; does not work at this dose in green iguanas ¹⁹⁷
Buprenorphine (Buprenex, Reckitt & Colman)	0.005–0.02 mg/kg IM q24–48h ⁹⁵	Most species/analgesia
	0.01 mg/kg IM ¹⁵⁵	Most species/analgesia
	0.1–1.0 mg/kg IM ¹⁹	Most species/analgesia
Butorphanol (Torbugesic, Fort Dodge)	—	Butorphanol combination follows; see ketamine for combinations
	0.4–1.0 mg/kg SC, IM ²²⁷	Most species/analgesia; sedation; preanesthetic; 0.2 mg/kg IM used experimentally in tortoises ⁹⁵
	0.5–2.0 mg/kg IM or 0.2–0.5 mg/kg IV, IO ¹⁹	Most species/preanesthetic
	1–2 mg/kg IM ¹⁹	Snakes/analgesia
	0.05 mg/kg IM q24h ×2–3 days ¹⁶⁴	Lizards (iguanas)/analgesia
	1.0–1.5 mg/kg SC, IM ²²⁷	Lizards/administer 30 min before isoflurane for smooth, shorter induction
Butorphanol (B)/midazolam (M)	(B) 0.4 mg/kg + (M) 2 mg/kg IM ¹⁸	Preanesthetic; administer 20 min before induction
Carprofen (Rimadyl, Pfizer)	1–4 mg/kg PO, SC, IM, IV q24h, ¹⁵⁵ follow with half the dose q24–72h ¹⁷⁸	Analgesia; nonsteroidal antiinflammatory
Chlorpromazine	0.1–0.5 mg/kg IM ⁸²	Most species/preanesthetic; not commonly used
	10 mg/kg IM ¹³	Chelonians/preanesthetic

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Diazepam	—	Diazepam combination follows; see ketamine for combinations	
	—	Muscle relaxation; give 20 min before anesthesia; potentially reversible with flumazenil	
	2.5 mg/kg IM, IV ²²⁰	Most species/seizures	
	0.2–0.8 mg/kg IM ²²⁷	Snakes/use in conjunction with ketamine for anesthesia with muscle relaxation	
	2.5 mg/kg PO ²²¹	Iguanas/reduces anxiety that often leads to aggression	
	0.2–1.0 mg/kg IM ²²⁷	Chelonians/use in conjunction with ketamine for anesthesia with muscle relaxation	
Diazepam (D)/succinylcholine (S)	(D) 0.2–0.6 mg/kg IM, followed in 20 min by (S) 0.14–0.37 mg/kg IM ²³⁴	Alligators	
Disoprofol	5–15 mg/kg IV to effect ³³	All species/anesthesia; similar characteristics to propofol; not available in the United States	
Doxapram	5 mg/kg IM, IV ¹⁸ q10min prn	Respiratory stimulant; reduces recovery time; reported to partially “reverse” effects of dissociatives ¹⁵⁸	74
	4–12 mg/kg IM, IV ²²⁷	Respiratory stimulant	
Etorphine (M-99, Wildlife Pharmaceuticals)	0.3–0.5 mg/kg IM ¹⁸⁷	Crocodylians, chelonians/very potent narcotic; crocodilians: induction, 5–30 min; duration, 30–180 min; chelonians: induction, 10–20 min; duration, 40–120 min; not very effective in reptiles other than alligators ¹⁹⁸ ; poor relaxation; adequate for immobilization and minor procedures; requires an antagonist; limited use because of expense and legal restrictions	75
	0.3–2.75 mg/kg IM ¹⁵⁴		
Flumazenil (Romazicon, Hoffman-LaRoche)	1 mg/20 mg of zolazepam, ¹⁵⁸ IM, IV ²¹²	Crocodylians, chelonians/reversal of zolazepam	
Flunixin meglumine (Banamine, Schering)	0.1–0.5 mg/kg IM q12–24h ¹⁵⁵ 1–2 mg/kg IM q24h ×2 treatments ^{33,240}	Most species/analgesia; use for maximum of 3 days	
		Lizards/postsurgical analgesia; see Table 18	
Gallamine (Flaxedil, American Cyanamid)	0.4–1.25 mg/kg IM ¹⁵ 0.6–4.0 mg/kg IM ¹⁵⁹ 0.7 mg/kg IM ¹⁸⁹ 1.2–2.0 mg/kg IM ⁸⁰	Crocodyles/results in flaccid paralysis but no analgesia; larger animals require the lower dosage; reverse with neostigmine; use in alligators questionable; unsafe in alligators at ≥1 mg/kg ¹⁹⁸	
Glycopyrrolate (Robinul-V, Robins)	0.01 mg/kg SC, ²⁷ IM, IV ¹⁸	Most species/preanesthetic; for excess oral or respiratory mucus; rarely indicated; generally use only in profound or prolonged bradycardia; may be preferable to atropine ⁸² ; does not work at this dose in the green iguana ¹⁹⁷	
Halothane	3%–4% induction, 1.5%–2.0% maintenance ^{27,82}	Most species/isoflurane preferred; in lizards, in particular, use lowest concentration needed	
Hyaluronidase (Wydase, Wyeth)	25 IU/dose SC ¹⁵⁸	Crocodylians/combine with premedication, anesthetic, or reversal drugs to accelerate SC absorption	75
Isoflurane	3%–5% induction, ¹²⁸ 1%–3% maintenance ^{1,34}	Most species/inhalation anesthetic of choice in reptiles; induction, 6–20 min; recovery, 30–60 min; not as smooth in reptiles compared with other animals; intubation and intermittent positive pressure ventilation advisable; may preanesthetize with low dose of propofol, ketamine, etc.	76

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Ketamine	— —	<p>Ketamine combinations follow</p> <p>Muscle relaxation and analgesia may be marginal; prolonged recovery with higher doses; larger reptiles require lower dose; painful at injection site; safety is questionable in debilitated patients; avoid use in cases with renal dysfunction; snakes may be permanently aggressive after ketamine anesthesia¹³; generally recommend use only as a preanesthetic before isoflurane for surgical anesthesia</p> <p>Most species/maintenance of anesthesia; recovery, 3–4 hr</p> <p>Most species/muscle relaxation improved with diazepam 2–5 mg/kg⁵²</p> <p>Most species/sedation</p> <p>Most species/surgical anesthesia; induction, 10–30 min; recovery, 24–96 hr</p> <p>Snakes/sedation; induction, 30 min; recovery, 2–48 hr</p> <p>Snakes/light anesthesia; intermittent positive pressure ventilation may be needed at the higher dose</p> <p>Lizards/decreases the incidence of breath-holding during chamber induction</p> <p>Lizards/sedation (e.g., facilitates endotracheal intubation); preanesthetic; requires lower dose than other reptiles</p>	76
	<p>10 mg/kg SC, IM q30min²⁷</p> <p>20–60 mg/kg IM, or 5–15 mg/kg IV¹²⁹</p> <p>22–44 mg/kg SC, IM^{13–15}</p> <p>55–88 mg/kg SC, IM^{14,15}</p> <p>20–60 mg/kg SC, IM^{27,133}</p> <p>60–80 mg/kg IM³⁴</p> <p>5–10 mg/kg IM²²⁷</p> <p>20–30 mg/kg IM⁷⁸</p> <p>30–50 mg/kg SC, IM^{27,133}</p> <p>20–60 mg/kg IM^{110,133,198}</p> <p>25 mg/kg IM, IV²⁵²</p> <p>38–71 mg/kg ICe²⁵⁷</p> <p>60–90 mg/kg IM^{133,187}</p> <p>20–40 mg/kg SC, IM, ICe (sedation) to 40–80 mg/kg (anesthesia)¹⁵⁸</p>	<p>Lizards/sedation; variable results</p> <p>Chelonians/sedation; induction, 30 min; recovery, ≥24 hr; potentially dangerous in dehydrated and debilitated tortoises</p> <p>Sea turtles/sedation; used at higher doses (50–70 mg/kg); recovery times may be excessively long and unpredictable; combination of ketamine and acepromazine gives a more rapid induction and recovery</p> <p>Green sea turtles/anesthesia; induction, 2–10 min; duration, 2–10 min; recovery, <30 min</p> <p>Chelonians/light anesthesia; induction, <30 min; recovery, hours to days; requires higher doses than most other reptiles</p> <p>Crocodilians/induction, <30–60 min; recovery, hours to days; in larger animals, 12–15 mg/kg may permit tracheal intubation²²⁷</p>	77
Ketamine (K)/butorphanol (B)	<p>See (K) dosages + (B) ≤1.5 mg/kg IM²²⁷</p> <p>(K) 10–30 mg/kg + (B) 0.5–1.5 mg/kg IM²²⁷</p>	<p>Snakes/anesthesia with improved muscle relaxation</p> <p>Chelonians/minor surgical procedures (e.g., shell repair)</p>	
Ketamine (K)/diazepam (D)	<p>See (K) dosages + (D) 0.2–0.8 mg/kg IM²²⁷</p> <p>(K) 60–80 mg/kg¹⁸⁷ + (D) 0.2–1.0 mg/kg IM²²⁷</p>	<p>Snakes/anesthesia with improved muscle relaxation</p> <p>Chelonians/anesthesia; muscle relaxation</p>	

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Ketamine (K)/medetomidine (M)	—	Reverse medetomidine with atipamezole	77
	(K) 10 mg/kg + (M) 0.1–0.3 mg/kg IM ⁶⁸	Most species	
	(K) 5–10 mg/kg IM + (M) 0.10–0.15 mg/kg IM, IV ⁹⁷	Lizards (iguanas)	
	(K) 3–8 mg/kg + (M) 0.025–0.080 mg/kg IV ¹⁶⁰	Giant tortoises (Aldabra)	
	(K) 4 mg/kg + (M) 0.04 mg/kg IM ¹⁰¹	Green sea turtles	
	(K) 5 mg/kg + (M) 0.05 mg/kg IV ⁴⁶	Loggerhead sea turtles/induction of anesthesia for intubation	78
	(K) 5 mg/kg + (M) 0.05 mg/kg IM ¹⁹⁴	Tortoises (gopher)/light anesthesia; tracheal intubation; inconsistent results	
	(K) 5–10 mg/kg IM + (M) 0.10–0.15 mg/kg IM, IV ⁹⁷	Tortoises (small-medium)	
	(K) 7.5 mg/kg + (M) 0.075 mg/kg IM ¹⁹⁴	Tortoises (gopher)/anesthesia; tracheal intubation	
	(K) 10–20 mg/kg IM + (M) 0.15–0.30 mg/kg IM, IV ⁹⁷	Turtles (freshwater)	
	(K) 5–10 mg/kg + (M) 0.1–0.15 mg/kg IM ¹⁰⁰	Alligators/adults	
Ketamine (K)/midazolam (M)	(K) 10–15 mg/kg + (M) 0.15–0.25 mg/kg IM ¹⁰⁰	Alligators/juveniles	
	(K) 20–40 mg/kg + (M) ≤2 mg/kg IM ²²	Chelonians/sedation; muscle relaxation	
Ketamine (K)/propofol (P)	(K) 60–80 mg/kg ¹⁸⁷ + (M) ≤2 mg/kg IM ²²⁷	Chelonians/anesthesia; muscle relaxation	
	(K) 25–30 mg/kg IM ¹⁸⁷ + (P) 7 mg/kg IV ²⁰⁶	Chelonians/administer propofol ~70–80 min after ketamine; see propofol	
Ketoprofen (Ketofen, Fort Dodge)	2 mg/kg SC, IM q24h ¹⁵⁵	Most species/analgesia	
Lidocaine (0.5%–2.0%)	Local or topical ²²⁷	Most species/local analgesia; infiltrate to effect (e.g., 0.01 ml 2% lidocaine used for local block for IO catheter placement in iguanas) ¹⁶ ; often used in conjunction with chemical immobilization	
Medetomidine (Dormitor, Pfizer)	—	See ketamine for combinations	
	—	Produces poor to no immobilization alone; reversible with atipamezole	
	0.10–0.15 mg/kg IM ¹⁸ 0.15 mg/kg IM ^{229,232}	Most species Crocodilians, desert tortoises/sedation; incomplete immobilization; generally produces bradycardia and bradypnea	
Meloxicam (Metacam, Boehringer Ingelheim Vetmed)	0.1–0.2 mg/kg PO q24h ¹⁵⁵	Most species/analgesia (orthopedic pain)	78
	0.2 mg/kg IM, IV	Lizards (green iguanas)/PD; parenteral dose lasts approximately 36 hr; author suggests 0.4 mg/kg PO q48h may be effective ^a	
Meperidine (Demerol, Winthrop-Breon)	5–10 mg/kg IM q12–24h ⁹⁵	Most species/analgesia; no noticeable effect in snakes, even at 200 mg/kg ¹³	79
	2–4 mg/kg ICe ³	Nile crocodiles/analgesia	
Methohexital (Brevital, Lilly)	5–20 mg/kg SC, IV ^{15,82}	Most species/induction, 5–30 min; recovery, 1–5 hr; use at 0.125%–0.5% concentration; much species variability; decrease dose 20%–30% for young animals; avoid use in debilitated animals	
	9–10 mg/kg SC, ¹⁹² ICe	Colubrids/induction, ≥22 min; recovery, 2–5 hr; does not produce soft tissue irritation seen with other barbiturates; may need to adjust dosage in obese snakes	
Methoxyflurane	3%–4% induction, 1.5%–2.0% maintenance ⁸²	Not commonly used	
Metomidate	10 mg/kg IM ^{69,225}	Snakes/profound sedation; not available in the United States	

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Midazolam (Versed, Roche)	—	See butorphanol, ketamine for combinations; potentially reversible by flumazenil Most species/preanesthetic; increases the efficacy of ketamine; effective in snapping turtles, not in painted turtles ¹⁵ Turtles (red-eared sliders)/sedation; onset, 5.5 min; duration, 82 min; recovery, 40 min; much individual variability	
	2 mg/kg IM ^{13,15}		
	1.5 mg/kg IM ¹⁹⁵		
Morphine	0.5–4.0 ICe ²³²	Crocodilians/analgesia	
Neostigmine (Neostigmine, Squibb)	0.063 mg/kg IV ¹⁵⁹ 0.03–0.25 mg/kg IM ¹⁵⁹ 0.07–0.14 mg/kg IM ¹⁸⁹	Crocodiles/gallamine reversal; may cause emesis and lacrimation; fast 24–48 hr before use; effects enhanced if combined with 75 mg hyaluronidase per dose when administered SC, IM	
Oxymorphone	0.025–0.10 mg/kg IV ⁸² 0.5–1.5 mg/kg IM ⁸²	Some species/analgesia; avoid in cases with hepatic or renal dysfunction; no noticeable effect in snakes, even at 1.5 mg/kg ¹³	79
	0.05–0.2 mg/kg SC, IM q12–48h ⁹⁵	Some species/analgesia	80
Pentazocine (Talwin, Upjohn)	2–5 mg/kg IM q6–24h ⁹⁵	Analgesia	
Pentobarbital	15–30 mg/kg ICe ¹⁸⁷ 10–18 mg/kg ICe ¹⁸⁷ 7.5–15.0 mg/kg ICe, or 8 mg/kg IM ^{13,187}	Snakes/induction, 30–60 min; duration, ≥2 hr; prolonged recovery (risk of occasional fatalities); venomous snakes require twice as much as nonvenomous snakes ¹³ ; avoid use in lizards Chelonians Crocodilians	
Pethidine	20 mg/kg IM q12–24h ¹⁵⁵	Analgesia; not available in the United States	
Prednisolone	2–5 mg/kg PO, IM ¹⁵⁵	Analgesia (chronic pain)	
Proparacaine (Ophthaine, Fort Dodge)	Topical to eye ¹⁶⁸	Desensitizes surface of eye; ineffective in animals with spectacles	
Propofol (Rapinivet, Pitman-Moore; Deprivan, Zeneca)	—	See ketamine for combination	
	—	Anesthesia; rapid, smooth induction; may give 15–25 min anesthesia and restraint in most species; rapid, excitement-free recovery; must be administered IV (slowly) (no inflammation if goes perivascularly); may be administered IO; dosages may be reduced by as much as 50% in premedicated (e.g., ketamine) animals; may cause apnea and bradycardia; intubation and assisted ventilation generally required; considered by many to be parenteral agent of choice for inducing anesthesia	
	5–10 mg/kg IV, intracardiac ^{6,225} 3–5 mg/kg IV, IO ^{96,97}	Snakes Lizards (e.g., iguanas)/intubation and minor diagnostic procedures; may need to give an additional increment in 3–5 min; less cardiopulmonary depression than occurs with higher doses	80

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	<p>5–10 mg/kg IV, IO²⁰</p> <p>10 mg/kg IV, IO^{20,69}</p> <p>2 mg/kg IV¹⁸</p> <p>12–15 mg/kg IV^{64,243}</p> <p>10–15 mg/kg IV¹⁵⁸</p>	<p>Iguanas/higher dose is recommended for induction for short-duration procedures or intubation</p> <p>Lizards, snakes/0.25 mg/kg/min may be given for maintenance¹²</p> <p>Giant tortoises</p> <p>Chelonians/lower dosages (5–10 mg/kg IV²²⁷) may be used; 1 mg/kg/min may be given for maintenance²²⁷</p> <p>Crocodilians/duration, 0.5–1.5 hr; maintain on gas anesthetics; experimental IM with hyaluronidase¹⁶⁷</p>	81
Rocuronium (Zemuron, Organon)	0.25–0.5 mg/kg IM ¹³⁶	Neuromuscular blocking agent; no analgesia; for intubation only and small, nonpainful procedures ¹³⁶	
Sevoflurane (Ultane, Abbott)	prn ^{96,216}	Most species/anesthesia; rapid induction and recovery when intubated	
Succinylcholine (Anectine, Burroughs Wellcome)	—	<p>No analgesia; narrow margin of safety; intermittent positive pressure ventilation generally required; paralysis occurs in 5–30 min; avoid if exposed to organophosphate parasitocides within last 30 days; administer minimal amount required to perform procedure; see diazepam for combinations</p> <p>Most species</p> <p>Chameleons</p> <p>Large lizards</p> <p>Chelonians/induction, 15–30 min; recovery, 45–90 min; facilitates intubation</p> <p>Box turtles/induction, 20–30 min</p> <p>Alligators/rapid onset; 3–5 mg/kg in smaller animals have been used¹⁴</p> <p>Crocodilians/variable induction and recovery periods</p>	81
Thiopental	19–31 mg/kg IV ²⁵⁷	Green sea turtles/anesthesia; induction, 5–10 min; recovery, <6 hr; erratic anesthesia	82

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Tiletamine/zolazepam (Telazol, Fort Dodge)	—	Sedation, anesthesia; severe respiratory depression possible (may need to ventilate) ³⁴ ; variable results; may have prolonged recovery; use lower end of dose range in heavier species; good for muscle relaxation before intubation ^{81,212} ; other anesthetic agents may be preferable Most species/sedation; induction, 9–15 min; recovery, 1–12 hr; adequate for most noninvasive procedures Most species Snakes/facilitates handling and intubation of large snakes; induction, 30–45 min; prolongs recovery Snakes, lizards/induction, 8–20 min; recovery, 2–10 hr; variable results; longer sedation and recovery times at 22° C than at 30° C ²⁴⁷ ; good sedation in boa constrictors at 25 mg/kg IM ²⁴⁷ ; generally need to supplement with inhalation agents for surgical anesthesia; some snakes died at 55 mg/kg Chelonians/sedation; induction, 8–20 min; does not produce satisfactory anesthesia even at 88 mg/kg ¹⁹⁸ Large tortoises/facilitates intubation; if light, mask with isoflurane rather than redosing Large crocodilians/may permit intubation Crocodilians	82
	—	Alligators/induction, >20 min; adequate for minor procedures	83
Xylazine	—	Infrequently used; variable effects; potentially reversible with yohimbine; preanesthetic for ketamine Most species Nile crocodiles	

a Hernandez-Divers S. Personal communication. 2004.

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TABLE 16 Hormones and steroids used in reptiles.

Agent	Dosage	Species/Comments
Arginine vasotocin (AVT) (Sigma Chemical)	0.01–1.0 µg/kg IV (preferred), ICe ¹⁵⁷ q12–24h × several treatments	Most species/dystocias; administer 30–60 min after Ca lactate/Ca glycerophosphate; more effective in reptiles than oxytocin but not commercially available for use in animals; higher doses have been reported; 0.5 µg/kg commonly recommended
Calcitonin (Miacalcin, Sandoz; Calcimar, Rhone-Poulenc Rorer)	1.5 IU/kg SC q8h ×14–21 days prn ⁸² 50 IU/kg IM, repeat in 14 days ^{17,246}	Most species (e.g., iguanas)/severe nutritional secondary hyperparathyroidism; administer after Ca supplementation; do not give if hypocalcemic
Dexamethasone	0.60–1.25 mg/kg IM, IV ⁸² 2–4 mg/kg IM, IV q24h ×3 days ²²⁸	Shock (septic/traumatic) Inflammatory, noninfectious respiratory disease
Dexamethasone sodium phosphate	0.10–0.25 mg/kg SC, IM, IV ⁸⁴	Shock (septic/traumatic)
Insulin	1–5 IU/kg IM, ICe q24–72h ²⁴² 5–10 IU/kg IM, ICe q24–72h ²⁴²	Snakes, chelonians/doses are empirical and must be adjusted based on response to therapy and serial blood glucose; doses administered ICe may take 24–48 hr before a response is noted Lizards, crocodilians/see above
Levothyroxine	0.02 mg/kg PO q48h ¹⁹³	Tortoises/hypothyroidism; stimulates feeding in debilitated tortoises
Nandrolone (Deca-Durabolin, Orgamox)	1 mg/kg IM q7–28d ⁶⁵	Anabolic steroid; reduces protein catabolism; may stimulate erythropoiesis
Oxytocin	— 1–10 IU/kg IM ^{78,129}	Dystocias; results are variable; works well in chelonians, less so in snakes and lizards; generally administer 1 hr after Ca administration; use multiple doses with caution Most species/higher end of the range is commonly used; may be repeated up to 3× at 90 min intervals with increasing dosage ¹¹⁴
	2 IU/kg IM q4–6h ×1–3 treatments ¹⁰ 1–5 IU/kg IM, ⁶³ repeat in 1 hr 1–2, ²⁹ 2–20, ^{84,176} or 10–20 ²⁸ IU/kg IM	Most species Lizards/alternatively, 5 IU/kg by slow IV or IO over 4–8 hr ⁶³ Chelonians
Prednisolone	2–5 mg/kg PO, IM ¹⁵⁵	Analgesia (chronic pain)
Prednisolone Na succinate (Solu-Delta Cortef, Pharmacia & Upjohn)	5–10 mg/kg IM, IV, ⁸⁰ IO ⁶⁵	Shock; brain swelling from hyperthermia; may help reduce nephrocalcinosis
Stanozolol (Winstrol-V, Winthrop)	5 mg/kg IM q7d prn ⁸⁴	Most species/anabolic steroid; management of catabolic disease states

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TABLE 17 Nutritional/mineral/fluid support used in reptiles.^a

Agent	Dosage	Species/Comments
Calcium	PO prn	Sources include crushed cuttlebone, oyster shell, Ca lactate, and other commercially available products ¹⁴³
Ca carbonate (Rep-Cal, RepCal Labs; Tums, SmithKline Beecham)	PO prn	Most species/Ca supplement
Ca glubionate (Neo-Calglucon, Sandoz; Calciquid, Breckenridge Pharmaceuticals; Calcionate, Rugby)	10 mg/kg PO q12–24h ³ prn	Most species/nutritional secondary hyperparathyroidism; hypocalcemia; dystocia
Ca gluconate	10–50 mg/kg IM ¹²⁸ 100 mg/kg SC, IM, ICe ^{10,246} q8h ¹⁷ 100–200 mg/kg SC, IM ²²⁹	Most species/hypocalcemia; dystocia Most species/nutritional secondary hyperparathyroidism; hypocalcemic muscle tremors; seizures or flaccid paresis in lizards; when patient is stable, switch to oral Ca Most species/nutritional secondary hyperparathyroidism; hypocalcemia; dystocia; lower end of dose is preferable
Ca gluconate/borogluconate	10–50 mg/kg IM ³	Most species/hypocalcemia; hypocalcemic dystocia
Ca lactate/Ca glycerophosphate (Calphosan, Glenwood)	1–5 mg/kg SC, IM ³ 10–25 mg/kg SC, IM ⁸⁴ 10 mg/kg SC, IM, ICe q24h ×1–7 days ^{8,17}	Most species/hypocalcemia; hypocalcemic dystocia Most species/hypocalcemia; dystocia Lizards (iguanas)/nutritional secondary hyperparathyroidism
Clinicare feline and canine (Abbott Laboratories)	PO prn	For omnivorous/herbivorous species, use canine formula; for carnivorous species, use feline formula; initially dilute 1:1 with water and gradually increase to full strength over 48 hr; generally precede nutritional supplementation with 48–96 hr of water or electrolyte solution PO ²⁶⁰
Critical Care for Herbivores (Oxbow Pet Products)	20 ml/kg PO ⁴¹	Herbivorous species/nutritional support; anorexia; debility; prepare according to directions
Crystalloid (nonlactated) solutions (Normo-Sol-R, Ceva; Plasma-Lyte, Baxter)	PO, SC, IV, ICe, EpiCe, IO prn ³³	Fluid therapy; can mix with equal parts 5% dextrose (if patient is hypoglycemic) or 0.45% NaCl for initial rehydration ³³
Dextrose (2.5%, 5%)	PO, SC, IV, ICe, EpiCe, IO prn ⁴¹	Fluid therapy; can mix with crystalloid solutions
Electrolyte solutions (Pedialyte, Ross; Gatorade, Gatorade Co)	20–30 ml/kg PO q24h ⁶²	Oral fluid therapy; anorexia
Emeraid Critical Care (Lafeber)	20 ml/kg PO ⁴¹	Most species (especially herbivores)/nutritional support, especially for severely debilitated, cachectic patients; prepare according to directions
Emeraid Nutri-Support (Lafeber)	20 ml/kg PO ⁴¹	Most species/nutritional support for debilitated patients

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Iodine	2–4 mg/kg PO q24h ×14–21 days, then q7d ⁸⁴	Herbivorous species/iodine deficiency (i.e., goiter); use in species maintained on a goitrogenic diet; alternatively, can use a balanced vitamin-mineral mixture or iodized salt (0.5% of feed) ¹⁴³	
Iron dextran	12 mg/kg IM 1–2×/wk ×45 days ²⁴⁸	Crocodilians/iron deficiency; also used in other species, but dose not established	
Lactated Ringer's solution (LRS)	10–25 ml/kg SC, IV, ¹⁶² ICe q24h ⁴¹	Fluid therapy; to prevent nephrotoxicity caused by aminoglycosides; use extracoelomically in chelonians; use in reptiles is controversial and nonlactated, mildly hypotonic fluids may be preferable ²⁰⁴	
Metronidazole	— 12.5–50.0 mg/kg PO ⁸² 50–100 mg/kg PO ¹³⁰	May stimulate appetite by affecting bacterial flora or protozoal levels Most species Chameleons	87
Nonlactated, mildly hypotonic solution	10–25 ml/kg SC, IV, ¹⁶² ICe q24h ⁴¹	Fluid therapy; can use a 50/50 combination of dextrose 5% in water and a nonlactated, isotonic multiple electrolyte solution (Normosol-R, Ceva; Plasma Lyte, Baxter); may be preferable to using a lactated solution ²⁰⁴	88
Ringer's solution for reptiles	— 10–25 ml/kg ICe q24h ⁸⁴ 15 (large reptiles) to 25 (small reptiles) ml/kg q24h or divided q12h for maintenance ¹⁰ 20 ml/kg q12h ¹⁰	Fluid therapy; 1 part LRS, 2 parts 2.5% dextrose/0.45% saline; or 1 part LRS, 1 part 5% dextrose, 1 part 0.9% saline ²⁵³ ; to prevent nephrotoxicity caused by aminoglycosides; can use epicoelomically in chelonians All species All species All species/severe dehydration	
Selenium	0.028 mg/kg IM ³	Lizards/deficiency; myopathy	
Sodium chloride (0.45%)	PO, SC, IV, ICe, EpiCe, IO prn ⁴¹	Fluid therapy; can mix with crystalloid solutions	
Vionate (ARC)	500 mg (1 tsp)/kg PO q24h ²²⁹	Most species/vitamin, mineral supplement	
Vitamin A (Aquasol A, Armour)	— 1000–5000 IU/kg IM q7–10d ×4 treatments ^{4,84} 2000 IU/kg PO, SC, IM q7–14d ×2–4 treatments ^{10,28,34,239} 2000 IU/30 g PO once, repeat in 7 days ^{91,98} 200 IU/kg ⁷² SC, IM	Hypovitaminosis A; may have value in infectious stomatitis; overdose may cause epidermal sloughing; for less severe cases (especially in chelonians); oral vitamin A can be supplied by cod liver oil (2 drops 2×/wk) or commercial reptile vitamin products ¹⁴³ Most species Most species Chameleons Turtles/hypovitaminosis A; give in conjunction with PO vitamin A (2000–10000 IU/kg feed DM)	88
Vitamins A, D ₃ , E (Vital E-A&D, Schering-Plough)	0.15 ml/kg IM, repeat in 21 days ¹²⁹ 0.3 ml/kg PO, then 0.06 ml/kg q7d ×3–4 treatments ²⁸	Most species/hypovitaminosis A, D ₃ , or E; product contains alcohol and may sting when administered; a product without alcohol can be compounded commercially Box turtles/hypovitaminosis A; parenteral use may result in hypervitaminosis A and D; given PO may enhance Ca uptake	89
Vitamin B complex	5–10 mg/kg SC, IM 25 mg thiamine/kg PO q24h ×3–7 days ¹⁰	Most species/appetite stimulant; hypovitaminosis B Most species/appetite stimulant; hypovitaminosis B	

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Vitamin B ₁ (thiamine)	25 mg/kg PO q24h prn ²²⁰ or ×3–7 days 30 g/kg feed fish PO ⁸⁴	Thiamine deficiency in piscivorous species Crocodilians/treat or prevent deficiency
Vitamin B ₁₂ (cyanocobalamin)	0.05 mg/kg SC, IM ⁸⁴	Snakes, lizards/appetite stimulant
Vitamin C	10–20 mg/kg SC, IM q24h ^{86,229} 100–250 mg/kg PO q24h ⁸⁶	All species/hypovitaminosis C; supportive therapy for bacterial infections; higher doses (i.e., 100 mg/kg) may be used for severe burns ¹⁸⁴ Most species/infectious stomatitis
Vitamin D ₃	— 200 IU/kg IM q4wk ¹⁴³ 1000 IU/kg IM, repeat in 1 wk ^{31,32,34} 200 IU/kg PO, IM q7d ^{8,17}	Nutritional secondary hyperparathyroidism; hypocalcemia; herbivores are sensitive to excess; excessive supplementation may result in soft-tissue calcification Most species Most species Lizards (e.g., iguanas)/PO may be safer than IM, but absorption may be poor
Vitamin E	1 IU/kg ⁷³ IM 25 mg/kg IM ⁷⁷	Most species/hypovitaminosis E Lizards/hypovitaminosis E (see Vitamins A, D ₃ , E)
Vitamin K ₁	0.25–0.50 mg/kg IM ¹²⁹	Most species/hypovitaminosis K ₁ ; coagulopathies

a Also see [Appendix 9](#).

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TABLE 18 Miscellaneous agents used in reptiles.

Agent	Dosage	Species/Comments
Allopurinol (Zyloprim, Glaxo Wellcome)	10 ¹⁷⁶ –20 ^{65,207} mg/kg PO q24h 50 mg/kg PO q24h ×30 days, then q72h ¹⁴⁷	Most species/gout; decreases production of uric acid ¹⁶³ ; long-term therapy; tortoises may respond best Chelonians
Aluminum hydroxide (Amphogel, Wyeth-Ayerst)	100 mg/kg PO q12–24h ¹⁶²	Hyperphosphatemia (associated with renal disease); decreases intestinal absorption of P; use cautiously in patients with gastric outlet obstruction
Amidotrizoate (Gastrografin, Squibb)	7.5 ml/kg PO ¹⁸⁵	Tortoises/gastrointestinal contrast agent; give by gavage; mean transit times: 2.6 hr at 30.6° C; 6.6 hr at 21.5° C
Aminophylline	2–4 mg/kg IM ⁸²	Bronchodilator
Atropine	0.01–0.04 mg/kg IM, IV q8–24h ¹⁸⁴ 0.1–0.2 mg/kg IM ¹²⁹ 0.2 mg/kg SC, IM ²²⁰	Dries up excess mucous secretions with infectious stomatitis Organophosphate toxicity prn Respiratory distress associated with excessive secretions
Barium sulfate	5–20 ml/kg PO ⁴²	Gastrointestinal contrast studies
Cimetidine	4 mg/kg PO, IM q8–12h ⁸⁴	Gastric and duodenal ulceration; esophagitis; gastroesophageal reflux; may use in renal failure to increase phosphate secretion ²¹⁸
Cisapride (Propulsid, Janssen)	0.5–2.0 mg/kg PO q24h ²⁴⁶	Motility modifier; gastrointestinal stasis; not commercially available in the United States; may be compounded; proven ineffective in desert tortoises at 1 mg/kg ²⁵¹
Cyanoacrylate (tissue glue) (Nexaband, Veterinary Products)	Topical ¹²⁹	Hemostasis of bleeding toenails
Cyanoacrylate (Nexaband Spray, Veterinary Products)	Topical ²³¹	May protect burns, noninfected lesions, surgical sites
Diocetyl Na sulfosuccinate	1–5 mg/kg PO ⁸⁶	Most species/constipation; use 1:20 dilution
Doxorubicin (Adriamycin, Pharmacia)	1 mg/kg IV q7d ×2 treatments, then q14d ×2 treatments, then q21d ×2 treatments ²¹⁷	Snakes/chemotherapy for sarcomas (also lymphomas, carcinomas, etc.); treatment periods variable
Ferric subsulfate powder (Kwik-Stop, ARC)	Topical ¹²⁹	Hemostasis (e.g., cut toenails)
Flunixin meglumine (Banamine, Schering)	— 0.1–0.5 mg/kg IM, IV q12–24h ×1–2 days ^{84,176} 0.5–1.0 mg/kg IM, IV q24–72h ⁹⁵ 2 mg/kg IM q24h ×2 treatments ^{33,240}	Nonsteroidal antiinflammatory; do not use in sea turtles because of potential for gastric ulcers ¹⁶² ; see Table 15 Nonsteroidal antiinflammatory; antipyretic Nonsteroidal antiinflammatory Iguanas/analgesia (postsurgery)
Furosemide	5 mg/kg PO, IM, IV q12–24h ^{84,129}	Diuretic for edema and pulmonary congestion
Hydrochlorothiazide (HydroDiuril, Merck)	1 mg/kg q24–72h ⁶⁵	Promotes diuresis; monitor hydration status
Iodine compound (Conray 280, Mallinckrodt)	500 mg/kg IV, IO ⁶⁵	Lizards/IV urography; take radiographs 0, 5, 15, 30, and 60 min postinjection

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Iohexol (240 mg I/ml; Omnipaque, Sanofi Winthrop)	5–20 ml/kg PO ⁴¹	Gastrointestinal contrast studies; nonionic, organic iodine solution; good alternative to barium ⁴² ; faster transit time than barium; can be diluted 1:1 with water	91
K-Y Jelly (Johnson & Johnson)	1–3 ml of 50% K-Y jelly and 50% warm water/100 g ⁵	Enema	
Lactulose	0.5 ml/kg PO q24h ²⁴¹	Lizards/fatty liver disease	
Liquid paraffin (medicinal)	20–30 ml (50:50 with electrolyte solution)/kg PO q24h ⁶²	Constipation; administer by gavage; use cautiously because of risk of regurgitation and aspiration; seldom indicated ⁴¹	
Methimazole (Tapazole, Lilly)	2 mg/kg q24h ×30 days ^{91,92}	Snakes/for excessive shedding from hyperthyroidism, limited success	91
Metoclopramide	0.06 mg/kg PO q24h ×7 days ^{62,246} 1–10 mg/kg PO q24h ²⁵⁸	Stimulates gastric motility Turtles/stimulates gastric motility; proven ineffective in desert tortoises at 1 mg/kg ²⁵¹	92
Mineral oil	PO prn	Constipation; use cautiously because of risk of regurgitation and aspiration; seldom indicated ⁴¹	
New Skin (Medtech)	Topical ²²⁰	Spray-on bandage	
Oral cleansing gel (Maxi-Guard Oragel, Addison Biological)	Topical ²³⁹	Stomatitis; periodontitis	
Pentobarbital	60–100 mg/kg IV, ICe ^{1,36}	Euthanasia	
Pentosan polysulfate sodium (Elmiron, Baker Norton)	0.83 mg/kg q22d ×4 treatments ¹⁰⁵	Arthritis; anecdotal	
Polyurethane barrier (Opsite Spray Bandage, Smith and Nephew, Quebec)	Topical ²³¹	Encourages healing of cutaneous wounds	
Potassium chloride	2 mEq/kg IV, ICe ¹⁷	Euthanasia; cardioplegic; administer after a euthanasia solution	
Probenecid (Parmed)	Not established ¹⁶³	Gout; increases uric acid excretion	
Silver nitrate	Topical ¹²⁹	Hemostasis (e.g., cut toenails)	
Silver sulfadiazine cream (Silvadene, Marion)	Topical q24–72h ^{166,203}	Broad-spectrum antibacterial for skin or oral cavity; dressing is generally not necessary	
Simethicone (Mylanta Liquid, Johnson & Johnson)	PO prn	Gastrointestinal disturbance (gas)	
Sodium bicarbonate	0.5–1.0 mg/kg IV ²⁴⁶	Hypoxic acidosis postanesthesia	
Sodium hypochlorite (3%)	Disinfectant	Disinfectant for cages, water bowls, etc.; rinse well after use	92
Sucralfate (Carafate, Hoechst & Marion Roussel)	500–1000 mg/kg PO q6–8h ⁸²	Oral, esophageal, gastric, and duodenal ulcers	93
Sulfapyrazone (Anturane, Novartis)	Not established ¹⁶³	Gout; increases uric acid excretion	
Tamoxifen 60-day time release pellets (Innovative Research of America)	Pellets containing 5 mg tamoxifen implants ICe ⁵⁹	Leopard geckos/inhibition of follicular development for 60 days if implanted before vitellogenesis	
Tegaderm (3M Health Care)	Topical ⁴¹	Wound dressing	93

APPENDIX 6 Hematologic and serum biochemical values of reptiles.

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Measurement	Boa Constrictor (<i>Boa constrictor</i>) ^{45,115,223}	Emerald Tree Boa (<i>Corallus caninus</i>) ¹¹⁵	Rainbow Boa (<i>Epicrates cenchiria</i>) ¹¹⁵
HEMATOLOGY			
PCV (%)	24–40	24 ±11	29 ±7
RBC (10 ⁶ /μl)	1.0–2.5	1.3 ±1.7	0.9 ±0.4
Hb (g/dl)	—	9.6 ±4.8	9.2 ±2.8
MCV (fl)	—	285 ±131	303 ±104
MCH (pg)	—	138 ±17	119 ±39
MCHC (g/dl)	—	40 ±11	31.4 ±7.5
WBC (10 ³ /μl)	4–10	5.0 ±3.7	9.4 ±7.7
Heterophils (%)	20–65 ^a	—	—
Lymphocytes (%)	10–60	—	—
Monocytes (%)	0–3	—	—
Azuropils (%)	1.5 (0–5.8)	—	—
Eosinophils (%)	0–3	—	—
Basophils (%)	0–20	—	—
CHEMISTRIES			
AP (IU/L)	421 (242–652)	109 ±72	85 ±169
ALT (IU/L)	6 (0–20)	5 ±4	11 ±11
AST (IU/L)	5–35	34 ±26	41 ±44
Bilirubin, total (mg/dl)	0.3 (0.2–0.4)	0.2 ±0.1	0.4 ±0.3
BUN (mg/dl)	<1–10	2 ±1	2 ±1
Calcium (mg/dl)	10–22	12.8 ±1.7	13.7 ±1.9
Chloride (mEq/L)	16.8 (14.1–23.7)	130 ±11	119 ±14
Cholesterol (mg/dl)	118 (104–124)	289 ±151	225 ±79
Creatine kinase (IU/L)	87 (53–138)	538 ±305	164 ±179
Creatinine (mg/dl)	<0.1–0.3	0.5 ±0.3	0.4 ±0.2
Glucose (mg/dl)	10–60	28 ±11	27 ±20
LDH (IU/L)	30–300	495 ±668	309 ±183
Magnesium (mEq/L)	—	—	—
Phosphorus (mg/dl)	3.6 (2.6–4.9)	4.5 ±2.2	5.2 ±1.3
Potassium (mEq/L)	3.0–5.7	4.9 ±1.6	3.6 ±1.4
Protein, total (g/dl)	4.6–8.0	4.7 ±1.5	6.5 ±1.4
Albumin (g/dl)	—	2.7 ±0.7	2.9 ±0.8
Globulin (g/dl)	—	2.8 ±0.7	3.9 ±0.8
A:G (ratio)	—	—	—
Sodium (mEq/L)	130–152	160 ±8	157 ±8
Uric acid (mg/dl)	1.2–5.8	5.6 ±5.2	6.0 ±5.6

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Measurement	Pythons ^b (<i>Python</i> spp.) ²²³	Ball Python (<i>Python regius</i>) ^{115,135}
HEMATOLOGY		
PCV (%)	25–40	18 (16–21)
RBC ($10^6/\mu\text{l}$)	1.0–2.5	—
Hb (g/dl)	—	6.7 (5.5–7.9)
MCV (fl)	—	—
MCH (pg)	—	—
MCHC (g/dl)	—	—
WBC ($10^3/\mu\text{l}$)	6–12	12.2 (7.9–16.4)
Heterophils (%)	20–80 ^a	62 (56–67)
Lymphocytes (%)	10–60	14 (7–21)
Monocytes (%)	0–3	1 (0–1)
Azurophils (%)	—	17 (12–22)
Eosinophils (%)	0–3	—
Basophils (%)	0–10	1 (0–2)
CHEMISTRIES		
AP (IU/L)	—	106 (96–116)
ALT (IU/L)	—	14 (12–16)
AST (IU/L)	5–30	33 (15–51)
Bilirubin, total (mg/dl)	—	0.3 \pm 0.6
BUN (mg/dl)	<1–10	2 \pm 1
Calcium (mg/dl)	10–22	14 (13–14)
Chloride (mEq/L)	—	120 \pm 6
Cholesterol (mg/dl)	—	124 \pm 85
Creatine kinase (IU/L)	—	—
Creatinine (mg/dl)	<0.1–0.3	0–0.5
Glucose (mg/dl)	10–60	29 (28–30)
LDH (IU/L)	40–300	263 \pm 209
Magnesium (mEq/L)	—	—
Phosphorus (mg/dl)	—	3.0 (2.7–3.4)
Potassium (mEq/L)	3.0–5.7	6.6 \pm 1.7
Protein, total (g/dl)	5–8	5.2 (5.0–5.6)
Albumin (g/dl)	—	—
Globulin (g/dl)	—	—
A:G (ratio)	—	—
Sodium (mEq/L)	130–152	157 \pm 8
Uric acid (mg/dl)	1.2–5.6	3.6 (3.2–4.1)

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Measurement	Green Tree Python (<i>Chondropython viridis</i>) ¹¹⁵	Jungle Carpet Python (<i>Morelia spilota cheynei</i>) ^{44,115}	Reticulated Python (<i>Python reticulatus</i>) ¹¹⁵
HEMATOLOGY			
PCV (%)	23 ±9	30 (23–37)	25 ±7
RBC (10 ⁶ /μl)	1.0 ±0.5	0.9 (0.5–1.3)	0.8 ±0.3
Hb (g/dl)	6.5 ±1.8	8.6 (4.0–15.5)	10.6 ±7.0
MCV (fl)	233 ±22	282 (178–414)	331 ±84
MCH (pg)	100	114 (67–159)	138 ±42
MCHC (g/dl)	35.0 ±3.3	40 (24–53)	37 ±5
WBC (10 ³ /μl)	8.8 ±6.1	8.5 (5.7–11.3)	8.0 ±4.6
Heterophils (%)	—	53 (38–68)	—
Lymphocytes (%)	—	43 (35–51)	—
Monocytes (%)	—	0 (0–1)	—
Azurophils (%)	—	2 (0–5)	—
Eosinophils (%)	—	0 (0–1)	—
Basophils (%)	—	1 (0–3)	—
CHEMISTRIES			
AP (IU/L)	178 ±111	36 ±14	84 ±56
ALT (IU/L)	43 ±59	19 ±11	27 ±22
AST (IU/L)	29 ±24	25 ±30	24 ±27
Bilirubin, total (mg/dl)	0.2	0.5	0.3 ±0.1
BUN (mg/dl)	2 ±1	2 ±1	3 ±2
Calcium (mg/dl)	14.0 ±2.2	26 ±27	18.8 ±8.6
Chloride (mEq/L)	128 ±8	112 ±6	122 ±12
Cholesterol (mg/dl)	204 ±96	333 ±117	263 ±86
Creatine kinase (IU/L)	524 ±300	479 ±431	1086 ±1817
Creatinine (mg/dl)	0.2 ±0.3	1.1 ±1.1	0.3 ±0.1
Glucose (mg/dl)	67 ±66	31 ±12	36 ±18
LDH (IU/L)	206	306 ±160	576 ±1592
Magnesium (mEq/L)	—	—	—
Phosphorus (mg/dl)	6.7 ±7.5	8.7 ±11.0	7.2 ±3.9
Potassium (mEq/L)	5.3 ±0.6	5.4 ±1.5	5.5 ±1.5
Protein, total (g/dl)	5.7 ±1.1	8.3 ±2.5	7.5 ±1.2
Albumin (g/dl)	2.0 ±0.7	3.0 ±1.2	2.9 ±1.3
Globulin (g/dl)	4.4 ±1.0	5.5 ±1.8	4.7 ±1.7
A:G (ratio)	—	—	—
Sodium (mEq/L)	160 ±3	149 ±7	160 ±8
Uric acid (mg/dl)	5.8 ±5.8	7.0 ±6.8	8.6 ±6.1

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Measurement	Gopher Snake (<i>Pituophis melanoleucus</i>) ^{82,115,171}	Red Rat Snake (<i>Elaphe guttata</i>) ¹¹⁵	Yellow Rat Snake (<i>Elaphe obsoleta quadrivittata</i>) ^{115,211}
HEMATOLOGY			
PCV (%)	29 ±7	31 ±7	25 ±8
RBC (10 ⁶ /μl)	0.90 ±0.34	1.16 ±0.42	0.75 ±0.32
Hb (g/dl)	10.1 ±1.7	11.5 ±1.9	8.9 ±4.0
MCV (fl)	349 ±100	291 ±83	385 ±156
MCH (pg)	148 ±17	128 ±17	134 ±44
MCHC (g/dl)	34 ±3	35 ±4	34 ±8
WBC (10 ³ /μl)	6.2 ±3.9	9.2 ±6.5	8.7 ±6.8
Heterophils (%)	—	—	—
Lymphocytes (%)	—	—	—
Monocytes (%)	—	—	—
Azuropils (%)	—	—	—
Eosinophils (%)	—	—	—
Basophils (%)	—	—	—
CHEMISTRIES			
AP (IU/L)	60 (9–133)	64 ±63	92 (55–130)
ALT (IU/L)	22 (11–65)	34 ±28	18 (7–29)
AST (IU/L)	53 (16–127)	42 ±46	59 (15–103)
Bilirubin, total (mg/dl)	0.2 ±0.1	0.6 ±0.4	0.3 ±0.2
BUN (mg/dl)	2 (1–5)	2 ±2	4 ±5
Calcium (mg/dl)	14.4 (13.0–15.7)	15.8 ±1.9	17.7 ±10.1
Chloride (mEq/L)	134 (109–148)	122 ±8	119 ±14
Cholesterol (mg/dl)	327 ±136	433 ±106	371 ±169
Creatine kinase (IU/L)	536 ±516	478 ±620	716 (200–1231)
Creatinine (mg/dl)	0.3 (0.1–0.6)	0.6 ±0.6	0.5 ±0.3
Glucose (mg/dl)	88 (24–129)	54 ±17	62 ±23
LDH (IU/L)	97 ±87	173 ±134	203 (86–320)
Magnesium (mEq/L)	—	—	2.5
Phosphorus (mg/dl)	4.1 (2.5–5.7)	3.8 ±1.2	4.4 ±2.7
Potassium (mEq/L)	6.6 (3.6–10.0)	6.8 ±3.4	5.0 ±1.9
Protein, total (g/dl)	4.3 (2.8–7.3)	6.6 ±1.0	6.6 ±1.6
Albumin (g/dl)	1.9 (1.6–2.1)	2.6 ±0.5	2.4 ±0.6
Globulin (g/dl)	—	4.4 ±0.7	4.3 ±1.2
A:G (ratio)	—	—	—
Sodium (mEq/L)	171 (161–180)	164 ±9	162
Uric acid (mg/dl)	6.7	7.0 ±4.9	6.6 ±5.3

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Measurement	Common Kingsnake (<i>Lampropeltis getulus</i>) ¹¹⁵	Milk Snake (<i>Lampropeltis triangulum</i>) ¹¹⁵	Indigo Snake (<i>Drymarchon corais</i>) ⁷⁴
HEMATOLOGY			
PCV (%)	30 ±8	27 ±9	—
RBC (10 ⁶ /μl)	2.7 ±4.6	0.9 ±0.4	—
Hb (g/dl)	—	10 ±2	—
MCV (fl)	318 ±118	369 ±120	—
MCH (pg)	—	119 ±28	—
MCHC (g/dl)	—	34 ±6	—
WBC (10 ³ /μl)	12.4 ±8.9	10.2 ±8.6	—
Heterophils (%)	—	—	—
Lymphocytes (%)	—	—	—
Monocytes (%)	—	—	—
Azuropils (%)	—	—	—
Eosinophils (%)	—	—	—
Basophils (%)	—	—	—
CHEMISTRIES			
AP (IU/L)	90 ±114	105 ±36	123 (80–161)
ALT (IU/L)	23 ±11	7 ±6	—
AST (IU/L)	40 ±32	29 ±31	46 (6–163)
Bilirubin, total (mg/dl)	0.2 ±0.2	0.5 ±0.3	—
BUN (mg/dl)	2 ±1	4 ±4	—
Calcium (mg/dl)	20 ±14	14.8 ±1.7	159 (30–337)
Chloride (mEq/L)	114 ±16	125 ±10	119 (100–129)
Cholesterol (mg/dl)	294 ±195	390 ±207	—
Creatine kinase (IU/L)	514 ±422	202 ±91	644 (68–1923)
Creatinine (mg/dl)	0.4 ±0.5	0.5 ±0.3	—
Glucose (mg/dl)	42 ±22	56 ±22	46 (28–89)
LDH (IU/L)	179 ±108	816 ±1193	313 (13–1055)
Magnesium (mEq/L)	—	—	—
Phosphorus (mg/dl)	6.2 ±4.8	7.3 ±6.6	35 (8–69)
Potassium (mEq/L)	4.9 ±1.7	5.3 ±2.4	8.1 (4.3–14.3)
Protein, total (g/dl)	7.1 ±1.8	6.6 ±1.9	8.9 (5.9–12.3)
Albumin (g/dl)	2.3 ±1.0	2.2 ±0.5	2.5 (1.7–4.6)
Globulin (g/dl)	4.6 ±1.2	5.2 ±1.7	—
A:G (ratio)	—	—	—
Sodium (mEq/L)	161 ±12	166 ±8	157 (143–170)
Uric acid (mg/dl)	7.1 ±5.6	7.4 ±7.4	8.6 (2.2–17.2)

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Measurement	Tokay Gecko (<i>Gecko gecko</i>) ¹¹⁵	Egyptian Spiny-Tailed Lizard (<i>Uromastyx aegyptius</i>) ¹¹⁵	Blue-Tongued Skink (<i>Tiliqua scincoides</i>) ¹¹⁵
HEMATOLOGY			
PCV (%)	30.3 ±2.4	27 ±6	30 ±6
RBC (10 ⁶ /μl)	0.7 ±0.1	0.7 ±0.2	1.1 ±0.3
Hb (g/dl)	—	5.8 ±2.3	10.4 ±3.2
MCV (fl)	467 ±25	308 ±65	299 ±32
MCH (pg)	—	87 ±8	98 ±55
MCHC (g/dl)	—	28 ±8	33 ±18
WBC (10 ³ /μl)	10.4 ±5.2	11.5 ±7.1	7.3 ±5.2
Heterophils (%)	—	—	—
Lymphocytes (%)	—	—	—
Monocytes (%)	—	—	—
Azuropils (%)	—	—	—
Eosinophils (%)	—	—	—
Basophils (%)	—	—	—
CHEMISTRIES			
AP (IU/L)	54	98 ±47	82 ±38
ALT (IU/L)	5	3	13 ±14
AST (IU/L)	61 ±74	37 ±20	45 ±29
Bilirubin, total (mg/dl)	0.5	0.3 ±0.3	—
BUN (mg/dl)	—	3 ±2	1 ±1
Calcium (mg/dl)	17.5 ±0.4	11.3 ±1.8	13.2 ±3.4
Chloride (mEq/L)	119	126 ±13	113 ±2
Cholesterol (mg/dl)	—	317 ±16	192 ±113
Creatine kinase (IU/L)	117	2003 ±1010	2099 ±2124
Creatinine (mg/dl)	—	0.3 ±0.1	0.3 ±0.2
Glucose (mg/dl)	141 ±31	184 ±53	130 ±34
LDH (IU/L)	189	639 ±383	735 ±525
Magnesium (mEq/L)	—	—	—
Phosphorus (mg/dl)	5.6 ±2.2	4.5 ±2.7	5.3 ±1.5
Potassium (mEq/L)	—	3.7 ±0.8	5.6 ±1.7
Protein, total (g/dl)	—	5.2 ±1.5	6.0 ±0.9
Albumin (g/dl)	2.7	1.6 ±0.6	2.0 ±0.5
Globulin (g/dl)	—	2.8 ±0.9	3.8 ±0.6
A:G (ratio)	—	—	—
Sodium (mEq/L)	158	173 ±4	148 ±6
Uric acid (mg/dl)	5.9 ±5.0	3.8 ±1.2	3.3 ±2.4

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Measurement	Bearded Dragon (<i>Pogona vitticeps</i>) ^{56,115}	Iguanid Lizard (<i>Dipsosaurus dorsalis</i>) ¹⁵⁰	Green Iguana (<i>Iguana iguana</i>) ^{70,82,106,115}
HEMATOLOGY			
PCV (%)	30 ±6	—	25–38
RBC (10 ⁶ /μl)	1.0 ±0.2	—	1.0–1.9
Hb (g/dl)	9.9 ±1.5	—	6–10
MCV (fl)	306 ±51	—	165–305
MCH (pg)	109 ±21	—	48–78
MCHC (g/dl)	35 ±8	—	20–38
WBC (10 ³ /μl)	8.5 ±5.4	—	3–10
Heterophils (%)	—	—	0.35–5.2 ^c
Lymphocytes (%)	—	—	0.5–5.5 ^c
Monocytes (%)	—	—	0–0.1 ^c
Azuropils (%)	—	—	0–1.7 ^c
Eosinophils (%)	—	—	0–0.3 ^c
Basophils (%)	—	—	0–0.5 ^c
CHEMISTRIES			
AP (IU/L)	151 ±129	14 (4–30)	50–290
ALT (IU/L)	11 ±5	13 (3–38)	5–68 ^d
AST (IU/L)	27 ±23	179 (34–400)	5–52 ^d
Bilirubin, total (mg/dl)	0.5 ±0.9	0.2 (0.1–0.5)	0.3 ±0.5
BUN (mg/dl)	2 ±1	2 (1–5)	2 ±2
Calcium (mg/dl)	16.2 ±11.2	11 (8–30)	8.8–14.0
Chloride (mEq/L)	126 ±15	120 (12–155)	117–122
Cholesterol (mg/dl)	425 ±194	243 (100–399)	104–333
Creatine kinase (IU/L)	1211 ±1574	4500 (700–14240)	1947 ±2058
Creatinine (mg/dl)	0.2 ±0.2	0.5 (0.2–1.8)	0.5 ±0.3 ^d
Glucose (mg/dl)	201 ±52	355 (255–575)	169–288
LDH (IU/L)	296 ±190	789 (145–2915)	443 ±648
Magnesium (mEq/L)	—	—	3.2 ±0.5 ^d
Phosphorus (mg/dl)	5.6 ±2.5	5.5 (2.8–10.0)	4–6 ¹⁶²
Potassium (mEq/L)	3.8 ±1.2	2.6 (0.4–7.0)	1.3–3.0 ^d
Protein, total (g/dl)	5.0 ±1.4	3.8 (2.4–5.4)	5.0–7.8
Albumin (g/dl)	2.6 ±0.8	2.3 (1.6–3.0)	2.1–2.8 ^d
Globulin (g/dl)	2.3 ±0.9	1.5 (0.8–2.4)	2.5–4.3
A:G (ratio)	—	1.7 (1.0–2.3)	—
Sodium (mEq/L)	156 ±11	164 (137–245)	158–183 ^d
Thyroxine (nmol/L)	—	—	2.98–4.65
Triglycerides (mg/dl)	310 ±172	—	53–691
Uric acid (mg/dl)	4.4 ±2.6	5.6 (2.4–13.3)	1.2–2.4 ^d

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Measurement	Green Iguana (<i>Iguana iguana</i>) Male (Outdoor) ^{e,93}	Green Iguana (<i>Iguana iguana</i>) Female (Outdoor) ^{e,93}	Green Iguana (<i>Iguana iguana</i>) Juvenile (Outdoor) ^{e,93}
HEMATOLOGY			
PCV (%)	34 (29–39)	38 (33–44)	38 (30–47)
RBC (10 ⁶ /μl)	1.3 (1.0–1.7)	1.4 (1.2–1.8)	1.4 (1.3–1.6)
Hb (g/dl)	8.6 (6.7–10.2)	10.6 (9.1–12.2)	9.6 (9.2–10.1)
MCV (fl)	266 (228–303)	270 (235–331)	—
MCHC (g/dl)	25 (23–28)	28 (25–31)	—
WBC (10 ³ /μl)	15 (11–25)	15 (8–25)	16 (8–22)
Heterophils (10 ³ /μl)	3.6 (1.0–5.4)	3.2 (0.6–6.4)	2.2 (1.0–3.8)
Lymphocytes (10 ³ /μl)	9.7 (5.0–16.5)	9.9 (5.2–14.4)	12.9 (6.2–17.2)
Monocytes (10 ³ /μl)	1.3 (0.2–2.7)	1.2 (0.4–2.3)	0.4 (0.3–0.6)
Eosinophils (10 ³ /μl)	0.1 (0.0–0.3)	0.1 (0.0–0.2)	0.3 (0.0–0.4)
Basophils (10 ³ /μl)	0.4 (0.1–1.0)	0.5 (0.2–1.2)	0.5 (0.1–0.7)
CHEMISTRIES			
Anion gap (mEq/L)	22 (12–30)	29 (19–41)	—
AP (IU/L)	39 (14–65)	59 (22–90)	—
ALT (IU/L)	32 (4–76)	45 (5–96)	—
AST (IU/L)	33 (19–65)	40 (7–102)	41 (13–72)
Bilirubin, total (mg/dl)	0.8 (0.1–1.4)	1.5 (0.3–3.1)	—
Calcium (mg/dl)	11.3 (8.6–14.1)	12.5 (10.8–14.0)	14.3 (12.1–23.2)
Chloride (mEq/L)	119 (115–124)	121 (113–129)	—
Cholesterol (mg/dl)	161 (82–214)	255 (204–347)	—
CO ₂ (mEq/L)	19.9 (15.2–24.7)	19 (16–23)	—
Glucose (mg/dl)	166 (70–244)	170 (105–258)	273 (131–335)
Phosphorus (mg/dl)	5.3 (3.2–7.6)	6.3 (2.8–9.3)	7.7 (4.3–9.0)
Potassium (mEq/L)	4.0 (2.8–6.1)	3.6 (2.0–5.8)	—
Protein, total (g/dl)	5.4 (4.4–6.5)	6.1 (4.9–7.6)	5.0 (4.2–6.1)
Albumin (g/dl)	2.0 (1.3–3.0)	2.4 (1.5–3.0)	2.3 (2.0–2.8)
Globulin (g/dl)	3.5 (2.5–4.4)	3.8 (2.8–5.2)	2.7 (2.2–3.0)
A:G (ratio)	0.6 (0.4–0.9)	0.7 (0.3–1.0)	0.8 (0.7–0.9)
Sodium (mEq/L)	157 (152–162)	163 (156–172)	—
Uric acid (mg/dl)	2.7 (1.5–5.8)	3.6 (0.9–6.7)	3.3 (0.7–5.7)

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Measurement	Prehensile-Tailed Skink (<i>Corucia</i> sp.) ²⁵⁹	Tegu Lizard (<i>Tupinambus</i> <i>teguixin</i>) ¹¹⁵	Green Crested Basilisk (<i>Basiliscus</i> <i>plumifrons</i>) ¹¹⁵
HEMATOLOGY			
PCV (%)	35 (24–60)	37 ±9	34 ±5
RBC (10 ⁶ /μl)	1.5 (0.8–1.4)	0.8 ±0.2	—
Hb (g/dl)	9.6 (7.4–11.6)	9.1 ±0.3	8.9 ±0.4
MCV (fl)	263 (152–600)	425 ±156	—
MCH (pg)	69 (42–111)	185 ±77	—
MCHC (g/dl)	28 (17–56)	39	26 ±5
WBC (10 ³ /μl)	12.4 (3.9–22.4) ^f	17.4 ±12.2	11.8 ±8.4
Heterophils (%)	37 (16–58)	—	—
Lymphocytes (%)	22 (2–40)	—	—
Monocytes (%)	0.6 (0–6)	—	—
Azurophils (%)	—	—	—
Eosinophils (%)	4 (0–18)	—	—
Basophils (%)	15 (4–26)	—	—
CHEMISTRIES			
AP (IU/L)	—	160 ±85	134 ±66
ALT (IU/L)	—	33 ±24	13 ±8
AST (IU/L)	19 (<4–76)	18 ±14	60 ±50
Bilirubin, total (mg/dl)	—	0.3 ±0.2	0.6 ±0.2
BUN (mg/dl)	—	1 ±1	5 ±8
Calcium (mg/dl)	13 (11–21)	12.2 ±0.8	10.0 ±2.1
Chloride (mEq/L)	124 (123–129)	121 ±7	127 ±2
Cholesterol (mg/dl)	144 (11–252)	206 ±67	845 ±256
Creatine kinase (IU/L)	210 (27–940)	641 ±568	5355 ±3589
Creatinine (mg/dl)	—	0.3 ±0.1	0.4 ±0.3
Glucose (mg/dl)	100 (70–122)	128 ±30	183 ±70
LDH (IU/L)	—	540 ±537	—
Magnesium (mEq/L)	—	—	—
Phosphorus (mg/dl)	3.7 (2.8–6.7)	5.6 ±2.1	9.5 ±2.0
Potassium (mEq/L)	3.6 (1.4–5.0)	2.4 ±1.4	3.0 ±0.6
Protein, total (g/dl)	6.5 (5–8)	6.6 ±1.3	5.7 ±1.6
Albumin (g/dl)	—	3.6 ±0.7	3.1 ±0.4
Globulin (g/dl)	—	2.9 ±1.2	2.9 ±1.4
A:G (ratio)	—	—	—
Sodium (mEq/L)	158 (145–167)	159 ±4	163 ±8
Uric acid (mg/dl)	1.6 (<0.3–3.1)	3.2 ±2.0	10.9 ±25.9

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Measurement	Savannah Monitor (<i>Varanus exanthematicus</i>) ¹¹⁵	Nile Monitor (<i>Varanus niloticus</i>) ¹¹⁵	American Alligator (<i>Alligator mississippiensis</i>) ^{82,115}
HEMATOLOGY			
PCV (%)	32 ±7	33 ±6	25 ±5
RBC (10 ⁶ /μl)	1.22 ±0.24	0.6	0.60 ±0.19
Hb (g/dl)	10.4 ±2.6	—	7.8 ±1.7
MCV (fl)	291 ±53	667	445 ±126
MCH (pg)	94 ±7	—	139 ±43
MCHC (g/dl)	32 ±4	—	32 ±6
WBC (10 ³ /μl)	4.8 ±2.5	8.2 ±7.0	9.0 ±5.2
Heterophils (%)	—	—	—
Lymphocytes (%)	—	—	—
Monocytes (%)	—	—	—
Azuropils (%)	—	—	—
Eosinophils (%)	—	—	—
Basophils (%)	—	—	—
CHEMISTRIES			
AP (IU/L)	77 ±136	79 ±37	39 ±24
ALT (IU/L)	58 ±88	75 ±109	39 ±27
AST (IU/L)	30 ±32	24 ±14	289 ±124
Bilirubin, total (mg/dl)	0.2 ±0.2	0.4 ±0.3	0.3 ±0.8
BUN (mg/dl)	2 ±2	2 ±1	2 ±3
Calcium (mg/dl)	14.3 ±1.4	12.8 ±1.4	11 ±1.7
Chloride (mEq/L)	115 ±7	111 ±6	110 ±13
Cholesterol (mg/dl)	117 ±60	57 ±8	94 ±46
Creatine kinase (IU/L)	1540 ±2325	1324 ±658	2022 ±2254
Creatinine (mg/dl)	0.4 ±0.2	0.3 ±0.2	0.4 ±0.3
Glucose (mg/dl)	109 ±24	137 ±33	91 ±35
LDH (IU/L)	596 ±976	375 ±215	485 ±499
Magnesium (mEq/L)	3.1	2.9	—
Phosphorus (mg/dl)	4.9 ±2.3	6.5 ±2.0	4.4 ±1.7
Potassium (mEq/L)	4.6 ±1.6	4.9 ±1.3	3.8 ±0.8
Protein, total (g/dl)	6.9 ±1.2	6.4 ±1.3	5.3 ±1.3
Albumin (g/dl)	2.1 ±0.5	2.1 ±0.5	1.6 ±0.4
Globulin (g/dl)	4.9 ±0.8	5.0 ±1.2	3.5 ±1.0
A:G (ratio)	—	—	—
Sodium (mEq/L)	155 ±5	164 ±7	146 ±16
Uric acid (mg/dl)	7.0 ±4.1	8.6 ±5.7	1.6 ±1.1

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Measurement	Dwarf Caiman (<i>Paleosuchus palpebrosus</i>) ¹¹⁵	Common Box Turtle (<i>Terrapene carolina</i>) ^{82,115,188,245}	Ornate Box Turtle (<i>Terrapene ornata</i>) ¹¹⁵
HEMATOLOGY			
PCV (%)	22 ±3	22 ±7	25 ±7
RBC (10 ⁶ /μl)	0.6 ±0.2	0.5 ±0.3	0.6 ±0.1
Hb (g/dl)	7.3 ±1.4	5.1 ±0.1	7.2 ±1.6
MCV (fl)	382 ±126	421 ±257	408 ±53
MCH (pg)	119 ±29	102	122 ±14
MCHC (g/dl)	31 ±6	28 ±3	32.5 ±1.3
WBC (10 ³ /μl)	5.7 ±2.2	7.0 ±4.6	8.9 ±6.5
Heterophils (%)	—	—	—
Lymphocytes (%)	—	—	—
Monocytes (%)	—	—	—
Azuropils (%)	—	—	—
Eosinophils (%)	—	—	—
Basophils (%)	—	—	—
CHEMISTRIES			
AP (IU/L)	13 ±7	62 ±27	88 ±36
ALT (IU/L)	52 ±21	7 ±6	30 ±16
AST (IU/L)	111 ±46	124 ±148	156 ±169
Bilirubin, total (mg/dl)	0.3 ±0.3	0.5 ±0.3	0.1
BUN (mg/dl)	2 ±1	49 ±29	38 ±27
Calcium (mg/dl)	11.3 ±1.3	13.6 ±5.1	10.4 ±2.1
Chloride (mEq/L)	119 ±10	106 ±5	105 ±6
Cholesterol (mg/dl)	127 ±71	240 ±157	167 ±95
Creatine kinase (IU/L)	2350 ±2659	463 ±337	1550 ±1934
Creatinine (mg/dl)	0.2 ±0.2	0.4	1.2 ±1.1
Glucose (mg/dl)	77 ±38	84 ±35	67 ±35
LDH (IU/L)	1986 ±2101	206 ±82	664 ±526
Magnesium (mEq/L)	—	3.5	—
Phosphorus (mg/dl)	5.3 ±2.6	4.0 ±1.5	3.8 ±0.8
Potassium (mEq/L)	4.6 ±1.1	5.6 ±2.4	6.6 ±2.0
Protein, total (g/dl)	5.5 ±1.1	5.6 ±1.4	4.4 ±1.3
Albumin (g/dl)	1.6 ±0.5	2.2 ±0.6	2.1 ±0.4
Globulin (g/dl)	4.1 ±0.6	3.4 ±0.9	2.5 ±1.1
A:G (ratio)	—	—	—
Sodium (mEq/L)	150 ±5	144 ±5	147 ±21
Uric acid (mg/dl)	2.2 ±1.0	1.6 ±1.0	2.0 ±2.2

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Measurement	Radiated Tortoise (<i>Geochelone radiata</i>) ^{115,175}	Red-Footed Tortoise (<i>Geochelone carbonaria</i>) ¹¹⁵	Star Tortoise (<i>Geochelone elegans</i>) ¹¹⁵
HEMATOLOGY			
PCV (%)	31 (19–45)	27 ±8	22 ±5
RBC (10 ⁶ /μl)	0.5 (0.4–0.7)	2.1 ±2.8	0.5 ±0.1
Hb (g/dl)	6.7 (4.5–8.6)	7.5 ±0.6	7.6 ±0.8
MCV (fl)	—	347 ±185	409 ±43
MCH (pg)	—	136 ±18	135 ±15
MCHC (g/dl)	—	30.6 ±1.8	31 ±3
WBC (10 ³ /μl)	4.3 (0.7–18)	7.8 ±4.1	12.3 ±10.2
Heterophils (%)	2.0 (0.7–3.4) ^f	—	—
Lymphocytes (%)	1.6 (0.4–3.4) ^f	—	—
Monocytes (%)	0.15 (0.030.47) ^f	—	—
Azuropils (%)	—	—	—
Eosinophils (%)	0.18 (0.030.53) ^f	—	—
Basophils (%)	0.34 (0.100.94) ^f	—	—
CHEMISTRIES			
AP (IU/L)	93 (72–120)	73 ±40	173 ±108
ALT (IU/L)	9 ±11	9 ±5	13 ±10
AST (IU/L)	73 (42–134)	214 ±152	96 ±68
Bilirubin, total (mg/dl)	0.2 ±0.1	0.5 ±0.3	0.2 ±0.2
BUN (mg/dl)	16 ±17	12 ±6	4 ±3
Calcium (mg/dl)	12.2 (10.8–14.4)	12.6 ±2.3	11.6 ±3.0
Chloride (mEq/L)	97 (92–99)	98 ±5	105 ±7
Cholesterol (mg/dl)	105 (60–154)	144 ±69	127 ±53
Creatine kinase (IU/L)	723 ±437	754 ±599	1099 ±1724
Creatinine (mg/dl)	0.3 ±0.4	0.3 ±0.1	0.3 ±0.1
Glucose (mg/dl)	60 (46–93)	91 ±39	115 ±42
LDH (IU/L)	402 (213–592)	428 ±228	667 ±297
Magnesium (mEq/L)	—	—	—
Phosphorus (mg/dl)	3.2 (2.6–4.3)	3.6 ±1.2	3.8 ±1.0
Potassium (mEq/L)	5.5 (5.1–5.8)	5.3 ±0.8	5.2 ±0.7
Protein, total (g/dl)	4.0 (3.2–5.0)	4.5 ±1.3	4.6 ±0.8
Albumin (g/dl)	1.1 (0.8–1.3)	1.7 ±0.5	1.5 ±0.8
Globulin (g/dl)	2.9	3.0 ±1.1	3.1 ±0.6
A:G (ratio)	0.38	—	—
Sodium (mEq/L)	127 (121–132)	128 ±5	131 ±7
Uric acid (mg/dl)	0.3 (0.0–0.6)	0.8 ±0.3	3.0 ±1.9

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Measurement	Desert Tortoise (<i>Gopherus agassizii</i>) ^{87,115,222}	Gopher Tortoise (<i>Gopherus polyphemus</i>) ²⁴⁹	Mediterranean Tortoises (<i>Testudo</i> spp.) ^{82,116,117}
HEMATOLOGY			
PCV (%)	23–37	23 (15–30)	28–34
RBC (10 ⁶ /μl)	1.2–3.0	0.54 (0.24–0.91)	0.7–1.0
Hb (g/dl)	6.9–7.7	6.4 (4.2–8.6)	9.1–11.3
MCV (fl)	377–607 ^g	—	384–944 ^g
MCH (pg)	113–126 ^g	—	125–314 ^g
MCHC (g/dl)	19–34 ^g	—	27–40 ^g
WBC (10 ³ /μl)	6.6–8.9	15.7 (10–22)	—
Heterophils (%)	35–60 ^h	30 (10–57)	—
Lymphocytes (%)	25–50 ^h	57 (32–79)	—
Monocytes (%)	0–4 ^h	7 (3–13)	—
Eosinophils (%)	0–4 ^h	—	—
Basophils (%)	2–15 ^h	6 (2–11)	—
CHEMISTRIES			
AP (IU/L)	32 (29–35)	39 (11–71)	—
ALT (IU/L)	6.1 (3.8–8.3)	15 (2–57)	—
AST (IU/L)	59 (47–70)	136 (57–392)	—
Bilirubin, total (mg/dl)	0.1 ±0.1	0.02 (0–0.1)	—
BUN (mg/dl)	46 (30–62)	30 (1–130)	—
Calcium (mg/dl)	10 (9.6–10.3)	12 (10–14)	2.3–4.0
Chloride (mEq/L)	110 (109–112)	102 (35–128)	95–100
Cholesterol (mg/dl)	74 (60–89)	76 (19–150)	—
Creatine kinase (IU/L)	2079 ±1783	160 (32–628)	—
Creatinine (mg/dl)	0.13 (0.12–0.14)	0.3 (0.1–0.4)	—
Glucose (mg/dl)	75 (69–82)	75 (55–128)	78
LDH (IU/L)	25–250	273 (18–909)	—
Magnesium (mEq/L)	2.1 (1.8–2.4)	4.1 (3.3–4.8)	—
Phosphorus (mg/dl)	2.2–4.5	2.1 (1.0–3.1)	—
Potassium (mEq/L)	3.7 (3.5–3.9)	5.0 (2.9–7.0)	4.4–7.8
Protein, total (g/dl)	3.6 (3.4–3.8)	3.1 (1.3–4.6)	6.6
Albumin (g/dl)	1.1 (1.0–1.2)	1.5 (0.5–2.6)	—
Globulin (g/dl)	2.5 (2.3–2.6)	—	—
A:G (ratio)	—	—	—
Sodium (mEq/L)	130–157	138 (127–148)	127
Uric acid (mg/dl)	2.2–9.2	3.5 (0.9–8.5)	—

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Measurement	African Spurred Tortoise (<i>Geochelone sulcata</i>) ¹¹⁵	Leopard Tortoise (<i>Geochelone pardalis</i>) ¹¹⁵	Aldabra Tortoise (<i>Geochelone</i> sp.) ^{115,224}
HEMATOLOGY			
PCV (%)	28 ±9	23 ±6	17 (11–27)
RBC (10 ⁶ /μl)	0.9 ±0.3	5.1 ±10.7	0.4 (0.3–0.7)
Hb (g/dl)	10.9 ±3.6	10.3 ±8.2	5.4 (3.2–8.0)
MCV (fl)	384 ±129	364 ±162	452 (375–537)
MCH (pg)	133 ±24	83	146 (118–185)
MCHC (g/dl)	36 ±12	33 ±9	33 (28–40)
WBC (10 ³ /μl)	7.2 ±6.1	8.8 ±5.7	3.4 (1.0–8.3)
Heterophils (%)	—	—	71 (32–79)
Lymphocytes (%)	—	—	22 (2–40)
Monocytes (%)	—	—	2 (0–8)
Eosinophils (%)	—	—	0.5 (0–7)
Basophils (%)	—	—	2 (0–4)
CHEMISTRIES			
AP (IU/L)	38 ±13	148 ±78	111 (29–182)
ALT (IU/L)	9 ±11	3 ±3	7 (0–26)
AST (IU/L)	114 ±93	79 ±74	57 (5–138)
Bilirubin, total (mg/dl)	0.4 ±0.8	0.2 ±0.1	0.2 (0–0.3)
BUN (mg/dl)	2 ±1	24 ±32	33 (21–57)
Calcium (mg/dl)	11.8 ±2.5	13.6 ±4.2	12 (6–20)
Chloride (mEq/L)	108 ±7	106 ±15	93 (87–107)
Cholesterol (mg/dl)	147 ±85	117 ±61	275 ±135
Creatine kinase (IU/L)	1228 ±1475	413 ±814	303 ±635
Creatinine (mg/dl)	0.3 ±0.1	0.4 ±0.2	0.1 (0.1–0.2)
Glucose (mg/dl)	139 ±56	85 ±45	50 ±16
LDH (IU/L)	1114 ±641	324 ±144	532 ±430
Magnesium (mEq/L)	—	—	5.1 ±0.3
Phosphorus (mg/dl)	3.9 ±1.4	3.4 ±1.5	4.3 (1.6–12.1)
Potassium (mEq/L)	5.5 ±1.7	6 ±1	4.7 (3.2–6.1)
Protein, total (g/dl)	4 ±1	3.2 ±0.8	4.1 (0.6–6.2)
Albumin (g/dl)	1.6 ±0.2	1.6 ±0.7	1.5 (0.3–2.6)
Globulin (g/dl)	2.1 ±0.4	2.2 ±1.0	2.6 (0.3–3.6)
A:G (ratio)	—	—	—
Sodium (mEq/L)	139 ±8	135 ±9	133 (129–136)
Uric acid (mg/dl)	5.1 ±2.4	3.1 ±1.9	1.6 (0–4.9)

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Measurement	Red-Eared Slider (<i>Trachemys scripta</i>) ^{57,82,115,117}	Painted Turtle (<i>Chrysemys picta</i>) ¹¹⁵
HEMATOLOGY		
PCV (%)	29 (25–33)	22 ±12
RBC (10 ⁶ /μl)	0.3–0.8	0.6 ±0.1
Hb (g/dl)	8.0	5.6
MCV (fl)	310–1000 ^g	271 ±91
MCH (pg)	95–308 ^g	—
MCHC (g/dl)	31 ^g	28
WBC (10 ³ /μl)	13 (3.5–25.5)	5.5 ±4.2
Heterophils (%)	—	—
Lymphocytes (%)	—	—
Monocytes (%)	—	—
Eosinophils (%)	—	—
Basophils (%)	—	—
CHEMISTRIES		
AP (IU/L)	212 (81–343)	208
ALT (IU/L)	16 ±22	—
AST (IU/L)	202 (0–419)	137 ±88
Bilirubin, total (mg/dl)	0.3 ±0.3	0.1
BUN (mg/dl)	22	20
Calcium (mg/dl)	14 (14–15)	11.4 ±4.2
Chloride (mEq/L)	102 (97–107)	95 ±5
Cholesterol (mg/dl)	167 ±43	—
Creatine kinase (IU/L)	1288 (1093–1483)	168 ±148
Creatinine (mg/dl)	0.3 ±0.1	1
Glucose (mg/dl)	67 (20–113)	98 ±35
LDH (IU/L)	3625 (2389–4861)	724 ±441
Magnesium (mEq/L)	2.2	—
Phosphorus (mg/dl)	4.0 (3.7–4.3)	4.8 ±6.0
Potassium (mEq/L)	6.3 (4.3–8.3)	2.9 ±0.3
Protein, total (g/dl)	4.5 ±1.1	3.2 ±1.6
Albumin (g/dl)	1.8 ±0.5	1.2
Globulin (g/dl)	2.6 ±0.9	1.2
A:G (ratio)	—	—
Sodium (mEq/L)	137 (133–140)	131 ±3
Uric acid (mg/dl)	1.2 ±0.7	1.0 ±0.7

a Heterophils and neutrophils.

b Includes Burmese (*Python molurus*), ball (*P. regius*), and reticulated (*P. reticulatus*) pythons.

c Absolute values (10³/μl).

d 191 Elevated in gravid females; vitamin D₃ higher in female green iguanas.

e In contrast to the data reported on the previous page in iguanas (housed indoors with 14 hr of artificial broad-spectrum lighting), these data were obtained from iguanas housed outdoors with natural sunlight much of the year.

f Includes 22 (8–42) azurophils.

g Calculated from data.

h Greatly differing percentages have also been reported: heterophils, 33 ±15; lymphocytes, 23 ±7; monocytes, 11 ±7; azurophilic monocytes, 2 ±2; eosinophils, 1 ±0.5; and basophils, 30 ±11.²

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APPENDIX 7 Environmental, dietary, and reproductive characteristics of reptiles.

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Species	Environmental Preference		Diet ^d	Method of Reproduction ^e	Gestation/Incubation Period (days) ^f
	Temperature ^{a,b,c}	RH (%)			
SNAKES	28° C–34° C (82° F–93° F)	50–70	C	V	120–240
Boa constrictor (<i>Boa constrictor</i>)					
Sand boa (<i>Eryx</i> sp.)	25° C–30° C (77° F–86° F)	20–30	C	V	120–180
Burmese (Indian) python (<i>Python molurus</i>)	25° C–30° C (77° F–86° F)	70–80	C	Ov	56–65
Ball (royal) python (<i>Python regius</i>)	25° C–30° C (77° F–86° F)	70–80	C	Ov	90
Garter snake (<i>Thamnophis sirtalis</i>)	22° C–30° C (72° F–86° F)	60–80	C	V	90–110
Kingsnake (<i>Lampropeltis getulus</i>)	23° C–30° C (73° F–86° F)	50–70	Op/c	Ov	50–60
CHELONIANS	20° C–27° C (68° F–81° F)	30–50	H/om	Ov	60
Spur-thighed tortoise (<i>Testudo graeca</i>)					
Common box tortoise (<i>Terrapene carolina</i>)	24° C–29° C (75° F–84° F)	60–80	C/f	Ov	50–90
Desert tortoise (<i>Gopherus agassizii</i>)	25° C–30° C (77° F–86° F)	—	H	Ov	84–120
Red-eared slider (<i>Trachemys scripta elegans</i>)	22° C–30° C (72° F–86° F)	80–90	C	Ov	59–93
Painted turtle (<i>Chrysemys picta</i>)	23° C–28° C (73° F–82° F)	—	H/I/o	Ov	47–99
Musk turtle (<i>Sternotherus odoratus</i>)	20° C–25° C (68° F–77° F)	—	O/i	Ov	60–87
LIZARDS	29° C–38° C (85° F–100° F)	60–80	H	Ov	73
Green iguana (<i>Iguana iguana</i>)					
Leopard ground gecko (<i>Eublepharis macularius</i>)	25° C–30° C (77° F–86° F)	20–30	I	Ov	55–60
Green anole (<i>Anolis carolinensis</i>)	23° C–29° C (73° F–84° F)	70–80	I/c	Ov	60–90
Jackson's chameleon (<i>Chamaeleo jacksonii</i>)	21° C–27° C (70° F–81° F)	50–70	I	V	90–180
Plumed basilisk (<i>Basiliscus plumifrons</i>)	23° C–30° C (73° F–86° F)	70–80	C/f	Ov	60–64
Water dragon (<i>Physignathus lesueurii</i>)	25° C–34° C (77° F–93° F)	80–90	I/om	Ov	90
Crocodilian American alligator (<i>Alligator mississippiensis</i>)	30° C–35° C (86° F–95° F)	—	C/p	Ov	62–65

C, Carnivorous; F, frugivorous; H, herbivorous; I, insectivorous; O, molluscivorous; Om, omnivorous; Op, ophiophagous; P, piscivorous; V, viviparous; Ov, oviparous.

^a Temperatures shown are ideal ambient daytime temperature gradients. These should be allowed to fall by approximately 5° C (9° F) during the night. “Hot-spot” temperatures should generally be 5° C (9° F) greater than the highest temperature shown.

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- b Preferred daytime temperature range for other commonly housed captive snakes are: rosy boa (*Lichanura trivirgata*), 27.0° C–29.5° C (81° F–85° F); green tree python (*Morelia viridis*), 24° C–28° C (75° F–82° F); carpet python (*Morelia spilota*), 27.0° C–29.5° C (81° F–85° F); corn snake (*Elaphe guttata*), 25° C–30° C (77° F–86° F); yellow rat snake (*Elaphe obsoleta*), 25° C–29° C (77° F–84° F); gopher/bullsnake (*Pituophis melanoleucus*): 25° C–29° C (77° F–84° F).
- c Preferred daytime temperature range for other commonly housed captive lizards are: day gecko (*Phelsuma* sp.), 29.5° C (85° F); chameleons (montane) (*Chamaeleo* spp.), 21° C–27° C (70° F–81° F); chameleons (lowland) (*Chamaeleo* spp.), 27° C–29° C (81° F–84° F); bearded dragon (*Pogona vitticeps*), 26.7° C–29.4° C (80° F–85° F); blue-tongued skink (*Tiliqua* sp.), 27.0° C–29.5° C (81° F–85° F); monitor lizards (*Varanus* spp.), 29° C–31° C (84° F–88° F); tegus (*Tupinambis* spp.), 27° C–30° C (81° F–86° F).
- d Uppercase letters denote principal dietary requirements. Lowercase denotes secondary preference.
- e Temperature-dependent.

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APPENDIX 8 Urinalysis values of chelonians.^{85,146}

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Measurement	Normal Values	Abnormal Values
Specific gravity	1.003–1.014 (mean, 1.008)	Up to 1.034 (mean, 1.013)
pH	6.4–6.6 (alkaline)	Acidic ^a
Color	Colorless to pale yellow	Yellow with white
Protein	Mild proteinuria	Increased proteinuria
Glucose	Glucosuria up to 30 mg/dl	Glucosuria can be higher than 50 mg/dl with anorexia
Renal casts	None	Various types present
Crystals	Amorphous urates/ammonium biurates	Many other crystals found in renal failure; uric acid crystals in gout; bilirubin and tyrosine crystals in liver disease

- a May be associated with anorexia or an improper diet.

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APPENDIX 9 Selected products and guidelines used in force-feeding anorectic or debilitated reptiles.^{a,b}

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Agent	Guidelines	Species/Comments
Alfalfa pellets (e.g., iguana or rabbit pellets) or powder (Alfalfa Powder, NOW Foods)	Blend (1:2–4) with electrolyte solution or water; 20 ml/kg PO q48h (lizards) to q84h (chelonians) ^{29,143,238}	Herbivorous species/administer by gavage; may clog feeding tube; for iguanas, may gavage equal volume of water on alternate days until patient is stable and eating ^{32,238} ; soaked pellets can also be hand fed (especially by owner)
Avian hand-feeding diets (various commercial)	20 ml/kg PO	Herbivorous species/administer by gavage; for short term, can use Emerald Critical Care (Lafeber) ²⁹ ; prepare product according to directions
Baby foods	Vegetable; blend in with other food sources Meat (small amount); blend in with other food sources	Herbivorous species/administer by gavage; for some species, some fruit baby food can be added Omnivorous species/administer by gavage
Barley powder (Green Powder, NOW Foods)	Blend with electrolyte solution or water	Herbivorous species/administer by gavage; higher fiber, lower Ca and P than alfalfa
Dog/cat food, canned (a/d, Hill's; Maximum-Calorie, Iams; Nutritional Recovery Formula, Eukanuba)	30 ml/kg PO q7–14d ^{41,139,143}	Carnivorous species/administer by gavage; although low protein (8.5%), some concern over high purine and vitamin A levels (probably OK unless concurrent renal disease); in dehydrated animals, dilute 1:1 with physiologic solution, pediatric oral human electrolyte solution (Pedialyte, Ross), or Gatorade (Gatorade); once stabilized, small whole animals (lubricated with egg white) can be force fed
Ensure (Ross) (strawberry or vanilla)	Blend 1 can with 1 banana and 1 vitamin tablet (Centrum, Lederle); 20 ml/kg q12–48h PO ⁹	Iguanas and other herbivorous species/administer by gavage; alfalfa meal (4 Tbs [54 g]) can be added
Electrolyte solutions (Pedialyte, Ross; Gatorade, Gatorade)	15–25 ml/kg PO q24h	Most species (see Table 17)
Timothy hay–based powder (Critical Care, Oxbow Pet Products)	Blend 1 part powder with 1.5 parts electrolyte solution or water; 20 ml/kg PO q48h (lizards) to q84h (chelonians) ^{29,143,238}	Herbivorous reptiles (e.g., iguanas, tortoises)

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a General guidelines for force-feeding: generally provide nutrition after rehydration of patient; needs may vary with specific disease (e.g., low protein with renal disease); force-feeding volumes are frequently started at a low/modest level and gradually brought up to the desired level (for patients with severe disease/cachexia, transition should be very gradual); concurrent to force-feeding and hydrating a patient, highly palatable food items should be provided for voluntary food intake.

b Dietary fiber supplements (alfalfa pellets or powder; barley powder; purified cellulose [Solka Floc, James River]) should be an integral part of enteral therapy for herbivorous reptiles.

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APPENDIX 10 Guidelines for tracheal/pulmonary and colonic lavage in reptiles. ^{98,130,210}

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SNAKES	
Tracheal/pulmonary lavage	Anesthesia often not necessary in debilitated animals; pass red rubber catheter through glottis to premeasured distance; infuse with 5–10 ml/kg sterile saline and massage the snake's body to loosen any debris; aspirate.
Colonic lavage	Pass lubricated soft red rubber catheter into cloaca; infuse with 10–20 ml/kg sterile saline; massage coelomic cavity and aspirate.
LIZARDS	
Tracheal/pulmonary lavage	General anesthesia typically necessary; intubate with sterile endotracheal tube; pass sterile catheter inside lumen (premeasure distance to sample site); infuse 1–5 ml/kg sterile saline and aspirate several times; not all fluid will be recovered.
Colonic lavage	Pass lubricated soft red rubber catheter into cloaca without excessive force; infuse 10 ml/kg sterile saline and aspirate several times.
CHELONIANS	
Tracheal/pulmonary lavage	Sedation or anesthesia may be necessary; pass catheter into affected lung lobe; may be helpful to bend it in the direction of the lobe before insertion; infuse with sterile saline at 5–10 ml/kg; aspirate.
Colonic lavage	Trepination of carapace is another option for accessing the appropriate lung lobe but is much more invasive. Pass lubricated red rubber catheter into cloaca; infuse with sterile saline at no more than 10 ml/kg; aspirate; repeat several times.

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APPENDIX 11 Venipuncture sites commonly used in reptiles. ^{107,215}

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SNAKES	
Ventral coccygeal vein	Ventral aspect of tail caudal to the cloaca under central scute; avoid hemipenes and anal sacs.
Heart	Dorsal recumbency, insertion of needle under central abdominal scute at 45° angle caudal to the heart.
Palatine pterygoid (lingual) veins	Not recommended; hematoma formation common.
LIZARDS	
Ventral coccygeal vein	Ventral aspect of vertebral body under center of middle scale; avoid hemipenes and anal sacs; this vein can also be approached laterally by inserting needle under lateral process of vertebral body aiming toward midline.
Ventral abdominal vein	Vein is located on the midline within the inner surface of the abdominal wall; insert 25-g needle (bent at 45° angle) cranially, at an acute angle to the skin and in the midline of the abdomen, just caudal to the umbilicus.
CHELONIANS	
Jugular vein	Right vein often larger than left; runs level with tympanum to base of neck with head extended.
Postoccipital vein and plexus	Lateral to cervical vertebrae, just cranial to carapace; contamination with lymph common.
Dorsal coccygeal vein	Close to carapace, dorsal to dorsal aspect of vertebral body; lymph dilution common.

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3.1 APPENDIX 12 Treatment of dystocia in reptiles. [a,3,8,35,82,120,143,176,208](#)

3.1.1 ETIOLOGY

- Poor environmental conditions (improper ambient temperature, lack of thermal gradient, lack of suitable nesting area, etc.)
- Dietary imbalances (e.g., calcium deficiency), malnutrition
- Endocrine imbalances
- Uterine inertia
- Renal disease
- Infections (e.g., uterus)
- Anatomic anomalies of the reproductive tract or eggs
- Other (substrate ingestion; overfeeding near oviposition; inadequate exercise)

3.1.2 DIAGNOSIS

- History and clinical signs
- Physical examination (gentle palpation)
- CBC, serum biochemical analysis
- Radiography (chelonian eggs have a calcified outer shell and appear radiographically similar to avian eggs; lizards and snakes generally have soft-shelled eggs with soft tissue density on radiographs)
- Ultrasound

3.1.3 TREATMENT

- Provide proper environmental conditions (adjust ambient temperature to the preferred body temperature; suitable nesting site; minimal stress)
- Gentle handling
- Warm water soaks ×30-60 min q24h
- Rehydration
- Dextrose (SC, IV, ICe) may be of value in some cases
- Calcium (see [Table 17](#)) (low Ca not generally a problem in snakes)
 - Ca lactate/Ca glycerophosphate (Calphosan, Glenwood) (5 mg each/ml), 5 mg/kg SC, IM

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- Ca gluconate (23%), 100-200 mg/kg SC, IM
 - Oxytocin (see [Table 16](#))^b
 - Generally administer 1 hr after Ca administration
 - 1-10 IU/kg IM, ICe in lizards and snakes (results are variable); 2-20 IU/kg IM, ICe for most chelonians; may be repeated in 1 hr
 - Arginine vasotocin (Sigma Chemical) (alternative to oxytocin) (See [Table 16](#))
 - 0.01-1.0 mg/kg IV (preferred), ICe
 - Appears to be more effective than oxytocin in many reptiles, but it is not commercially available for use in animals
 - Lubricate cloaca with water-soluble gel
 - Manual massage may be useful in some situations
 - Salpingostomy may be required
- a Although most reptiles are oviparous, some, including garter snakes, water snakes, boas (not pythons), vipers, Jackson's chameleons, horned toads, and Solomon Island prehensile-tailed skinks are viviparous.
- b Use only if there is no evidence of obstructive dystocia or broken eggs.

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3.2 APPENDIX 13 Treatment of nutritional secondary hyperparathyroidism in iguanas.^{3,5,8-10,30-32,161,238}

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3.2.1 ETIOLOGY

- Improper Ca:P ratio; lack of dietary Ca
- Lack of vitamin D₃
- Lack of UVB light in the 290-320 nm (285-315 nm)⁷¹ spectrum
- Other: low ambient temperature; protein deficiency; disease of kidney, small intestines, parathyroid, etc.

3.2.2 CLINICAL SIGNS

- Lethargy, reluctance to move
- Poor appetite or anorexia

- Weight loss or poor weight gain
- Softening of the mandible; shortened/rounded mandible and maxilla; symmetrical swelling of the mandible (fibrous osteodystrophy)
- Fibrous osteodystrophy of the long bones of the legs
- Difficulty in lifting body off ground when walking
- Pathologic fractures
- Ataxia, paresis, or paralysis of the rear legs from collapsed vertebrae or vertebral luxation
- Osteoporosis
- Hypocalcemic muscle fasciculations and seizures

3.2.3 DIAGNOSIS

- Dietary and environmental history
- Clinical signs
- Physical examination
- Radiography
- Serum Ca:P ratio; but is usually within normal limits

3.2.4 TREATMENT

- Provide ambient temperature (with temperature gradient) of 29.5° C–32.0° C (85° F–90° F) during the day and 24.0° C–26.5° C (75° F–80° F) at night
 - Focal hot spot should approach $\geq 37.5^{\circ}\text{C}$ (100° F)
- Improve diet (iguanas are herbivores/folivores, and require high-Ca foods)
- Force-feeding (after rehydration) (see [Appendix 9](#))
 - 20 ml/kg q1-2d
 - Vegetable baby foods; Critical Care (Oxbow Pet Products); blended iguana or rabbit pellets; avian hand-feeding formulas; short-term use of Emeraid Critical Care (Lafeber)
 - Alternatively, force-feed a formula consisting of 1 can strawberry or vanilla human liquid-meal replacement drink (Ensure or Enrich, Ross), 1 banana, and 1 Centrum vitamin tablet (Lederle) blended
 - In addition, pelleted commercial iguana chow can be soaked in water and gently hand-fed (especially by owners)

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<ul style="list-style-type: none"> • Ca supplementation options (see Table 17) <ul style="list-style-type: none"> • Per os (administered in conjunction with parenteral therapy) <ul style="list-style-type: none"> • Ca glubionate (Neo-Calglucon, Sandoz; Calciquad, Breckenridge Pharmaceuticals; Calcionate, Rugby), 10 mg/kg PO q12-24h until patient is gaining weight and consuming adequate Ca (generally 1-3 mo) • Sprinkled on food (Ca carbonate; Rep-Cal, Rep-Cal Research Labs; Tums, SmithKline Beecham) 	117
<ul style="list-style-type: none"> • In cases of hypocalcemia, extreme weakness, or when Ca absorption from the gastrointestinal tract may be poor, parenteral administration of Ca is indicated <ul style="list-style-type: none"> • Ca lactate/Ca glycerophosphate (Calphosan, Glenwood) (5 mg each/ml): 10 mg (1 ml)/kg SC, IM, ICE q24h × 1-7 days • Ca gluconate: 100 mg/kg IM, ICE q8h prn • Maintain hydration <ul style="list-style-type: none"> • Fluid therapy as needed • Soak in warm water (shallow) for 10-20 min q12-24h to encourage drinking and defecation (caution: head may need to be supported; do not leave unattended) • Vitamin D₃ <ul style="list-style-type: none"> • 100-1000 IU/kg (generally 200 IU/kg) IM (repeat in 1 wk) • 200 IU/kg PO q7d • Best source is UV radiation • Calcitonin (Miacalcin, Sandoz; Calcimar, Rhône-Poulenc Rorer) to prevent further transfer of Ca from bone to blood (hormone therapies should always be performed cautiously) <ul style="list-style-type: none"> • 50 IU/kg IM q7d × 2 treatments • Ca supplementation should be given before and during calcitonin therapy • Serum Ca should be within normal limits before calcitonin therapy; if Ca levels cannot be determined, administer Ca supplements for 7 days before calcitonin • Other <ul style="list-style-type: none"> • Handle gently • Remove climbing branches to prevent injuries 	118

3.3 APPENDIX 14 Selected sources of diets and other commercial products for reptiles.^{a,b}

3.3.1 FOODS AND SUPPLEMENTS

Five Star Diets	800-747-0557
Fluker Farms	800-735-8537
Drs Foster & Smith	800-443-1160
Kaytee	800-529-8331
LM Tropical Magic	800-332-5623
Mazuri	800-227-8941
Pretty Pets	800-356-5020
Rep-Cal	408-356-4289
San Francisco Bay Brand	510-792-7200
Sticky Tongue Farms	909-672-3876
Zoo Med	888-496-6633
ZuPreem	800-345-4767

3.3.2 LIVE/FROZEN FOODS FOR CARNIVORES

Bayou Rodents	800-722-6102	Frozen mice, rats
Carolina Mouse Farm	864-944-6192	Frozen mice, rats
Essex Pets	800-336-6423	Frozen mice, rats
G&A Frozen Rodents	718-456-0067	Frozen mice, rats, chicks
Perfect Pets Inc.	800-366-8794	Frozen mice, rats, chicks, guinea pigs, gerbils
Pinkies & Fuzzies	903-683-5212	Frozen mice
The Gourmet Rodent Inc	352-495-9024	Frozen mice, rats
The Mouse Factory	432-837-7100	Live and frozen mice, rats

3.3.3 LIVE FOODS FOR INSECTIVORES

Arbico	800-827-2847	Crickets, mealworms, waxworms, flies
Bassett's	800-634-2445	Crickets, mealworms
Drosophila	800-545-2303	Fruitflies
Fluker Farms	800-735-8537	Crickets, mealworms, fruit flies
Ghann's Cricket Farm	800-476-2248	Crickets, mealworms
Grubco	800-222-3563	Crickets, mealworms, fly larvae, waxworms, superworms
Millbrook Cricket Farm	800-654-3506	Crickets, mealworms
Rainbow Mealworms	800-777-9676	Crickets, mealworms
Russell's Cricket Farm	800-224-4668	Crickets
Sunshine Mealworms	800-322-1100	Crickets, mealworms
Top Hat Cricket	800-638-2555	Crickets, mealworms, waxworms
Topline Wholesale Dist. Co.	888-922-0464	Worms, roaches

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3.3.4 LIGHTS

Chromolux	800-788-5781	Incandescent, heat
Energy Savers Unlimited	310-851-8999	UV coil lamp
Fluker Farms	800-735-8537	Incandescent, heat
General Electric	800-688-5826	Fluorescent (Vita-Lite), incandescent, basking, heat
Hikari Sales USA	800-621-5619	UV lighting
Nature's Zone	800-782-3766	UV heat lamp
T-Rex Products	800-991-TREX	UV heat lamp
Wild Inside	775-573-2352	UV heat lamp
Zoo Med	888-496-6633 or 805-542-9988	Fluorescent (Reptisun, Iguana Light), heat/basking, incandescent

3.3.5 HEATING DEVICES

Fluker Farms	800-735-8537	Under-cage heaters
Helix Controls	619-566-8335	Thermostats, temperature controls, heating systems
The Bean Farm	425-861-7964	Heat pads
Zoo Med	888-496-6633	Temperature controls

a Many pet stores sell live and frozen food for reptiles and many of the products listed.

b Numerous sources of information were used to compile this table, especially references [41](#) and [201](#).

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3.4 APPENDIX 15 Literature cited—reptiles.

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Birds

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TABLE 19 Antimicrobial agents used in birds.^a

Agent	Dosage	Species/Comments
Amikacin (Amiglyde, Aveco; Amikin, Bristol Labs)	—	Least nephrotoxic of the aminoglycosides ¹¹⁹ ; active against gram-negative bacteria including <i>Pseudomonas</i> , and gram-positive bacteria including <i>Staphylococcus</i> and <i>Streptococcus</i> ; maintain hydration during use ⁴
	7 mg/kg IV q24h ²⁵⁶	Emus/PD; mean serum levels declined below a target trough of 4 µg/ml at 24 hr
	7.6 mg/kg IM q8h ²⁹⁰	Ostriches/PD; causes myositis; painful injection
	10 mg/kg IM q12h ⁴⁴⁶	Cranes
	10 mg/kg SC, IM q8h × 14 days ³²⁶	Ring-necked pheasants/PD; renal toxicosis appeared at 11 days; uric acid levels abnormal up to 7 days after cessation
	10–15 mg/kg IM q24h ²⁷⁰	Raptors
	10–15 mg/kg IM q12h ³⁷²	Amazon parrots, cockatiels, cockatoos/PD
	10–15 mg/kg IM, IV q8–12h ^{546,611}	Most species including psittacines
	10–20 mg/kg IM, IV q8–12h ²²⁴	African grey parrots/PD
	15 mg/kg IM q12h ⁵⁵⁵	Blue-fronted Amazon parrots/PD
	15 mg/kg IV q8h ⁵⁵⁵	Blue-fronted Amazon parrots/PD
	15–20 mg/kg/day divided q8–24h ⁵¹	Red-tailed hawks/PD; use low end of dose range for smaller hawks
	15–20 mg/kg SC, IM, IV q8–12h ¹⁴⁵	Passerines, pigeons/5 days maximum ⁵³⁹
	15–20 mg/kg IM q8–12h ⁵⁰⁰	Cockatiels/PD
	15–30 mg/kg IM q12–24h ^{145,620}	Most species, including passerines/use in combination with other agents for <i>Mycobacterium</i> ; see Appendix 42
	20 mg/kg IM q12h ¹	Ostriches (chicks)/administer concurrent with piperacillin (100 mg/kg q12h)
	20 mg/kg IM q8h ¹⁵⁴	Chickens/PD
	528 mg/L drinking water ⁶¹²	Ratites/egg dip
Amoxicillin/clavulanate (Clavamox, Pfizer; Augmentin, SmithKline Beecham)	—	β-Lactamase inhibitor; use with allopurinol is contraindicated ⁴
	7–14 mg/kg IM q24h ⁷²	Ostriches
	10–15 mg/kg PO q12h ⁶¹²	Ratites
	60–120 mg/kg IM q8–12h ¹⁴⁶	Collared doves/PD
	125 mg/kg PO q12h ^{191,471}	Most species, including pigeons, psittacines, raptors
	125 mg/kg PO q8h ⁴⁵²	Blue-fronted Amazon parrots/PD
	125–250 mg/kg PO q8–12h ¹⁴⁶	Collared doves/PD
	125 mg/kg PO q6h ¹⁰⁶	Psittacines
	500 mg/L drinking water ⁶⁶⁰	Chickens/PD
Amoxicillin sodium	50 mg/kg IM q12–24h ¹⁴⁴	Pigeons/PD; gram-positive bacteria
	100 mg/kg IM, IV q4–8h ⁵⁴⁶	Bustards/PD; administer q4h IM or q8h IV to maintain blood levels >2 µg/ml
	150 mg/kg IM q8h ⁵⁴²	Passerines, soft bills
	250 mg/kg IM q12–24h ^{140,144}	Pigeons/PD; gram-positive and gram-negative bacteria

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Amoxicillin trihydrate (Amoxicil, GlaxoSmithKline; Amoxi-inject, Amoxi-tabs, Amoxi-drops, Pfizer)	—	Broad-spectrum bactericidal penicillin antibiotic ⁴ ; minimal activity for common gram-negative infections of birds ⁵⁴⁶ ; penicillins in birds are more dependent on biotransformation for elimination than in mammals; because amoxicillin has a relatively low availability after oral administration, higher doses are needed in birds to achieve the same peak levels as in mammals ¹⁴⁹	
	15–22 mg/kg PO q8h ⁶¹²	Ratites	
	20 mg/kg PO q12–24h ¹⁴²	Pigeons/PD; mean half-life 66 min	
	30 mg/kg IM q12h × 5 days ⁷²	Pigeons	
	40–80 mg/kg PO q12h × 5 days ⁷²	Pigeons	
	55–110 mg/kg PO q12h ²³³	Poultry	
	100 mg/kg PO q12–24h ¹⁴⁵	Pigeons/PD	136
	100 mg/kg PO q8h ³⁸	Most species, including raptors	137
	100–150 mg/kg PO q12h ¹⁰⁷	Raptors	
	100–200 mg/kg PO, IM q4–8h ¹⁷⁴	Pigeons	
	150 mg/kg SC, IM q24h × 5 days (administer q48h with long-acting preparation) ⁵⁴⁶	Pigeons	
	150 mg/kg PO, IV ⁵⁶⁹	Pigeons/PD; <i>Streptococcus bovis</i>	
	150–175 mg/kg PO q12h ^{106,311}	Passerines (towhee), psittacines	
	150–175 mg/kg PO q4–8h ^{542,611}	Pigeons; psittacines	
	65 mg/L drinking water ⁶¹²	Ratites	
	200–400 mg/L drinking water ²³⁰	Canaries/aviary use	
	330 mg/L drinking water, ⁴⁴ provide on alternate days × 3 treatments ⁸³	Waterfowl	
	500–800 mg/L drinking water ²³³	Pigeons	
	1500 mg/L drinking water × 5 days ⁵⁶⁹	Pigeons/ <i>S. bovis</i>	
	1500–4500 mg/L drinking water ¹⁰⁶	Psittacines	
	300–500 mg/kg soft feed ²³⁰	Canaries/aviary use	
	600 mg/kg soft feed ¹⁰⁶	Psittacines	
Ampicillin sodium (Omnipen-N, Wyeth-Ayerst; Polycillin-N, Apotecocon)	50 mg/kg IM q6–8h ¹⁵⁶	Amazon parrots/PD; localized infections	
	100 mg/kg IM q4h ¹⁵⁶	Amazon parrots/PD	
	150 mg/kg q12–24h ^{140,144}	Passerines, soft bills	
	150 mg/kg IM q12–24h ¹⁴³	Pigeons/PD	
	150–200 mg/kg PO q8–12h ¹⁵⁶	Amazon parrots/PD; therapeutic levels not achieved in blue-naped Amazons at this dosage	
	174 mg/kg/day PO ¹³¹	Pigeons/PD; <i>S. bovis</i>	
	528 mg/L drinking water ¹³¹	Pigeons/PD; <i>S. bovis</i>	137

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Ampicillin trihydrate (Omnipen, Wyeth-Ayerst; Polycillin, Apothecon)	—	Broad-spectrum bactericidal penicillin antibiotic; minimal activity for common gram-negative infections of birds; poor gastrointestinal absorption; may be useful for treating sensitive gastrointestinal infections ⁵⁴⁶ Ratites (excluding emus) Ratites Raptors/PD Emus, cranes/PD in cranes Pigeons/PD Poultry Pigeon/PD Cranes Most species, including psittacines Psittacines Pigeons/PD; amoxicillin preferred over ampicillin for IM use in pigeons Game birds Galliformes/flock use Canaries/aviary use Canaries/aviary use	138
	4–7 mg/kg SC, IM q8h ⁶¹² 11–15 mg/kg PO q8h ⁶¹² 15 mg/kg IM q12h ⁷¹ 15–20 mg/kg SC, IM q12h ^{71,291,396} 25 mg/kg PO q12–24h ^{140,144} 55–110 mg/kg IM q8–12h ²³³ 100 mg/kg PO q12–24h ^{140,144} 100 mg/kg IM q12h ⁴⁴⁶ 100 mg/kg IM q4h ^{95,546,611} 100–200 mg/kg PO q6–8h ^{546,611} 155 mg/kg IM q12–24h ¹⁵⁰ 170 mg/L drinking water ⁷² 1000 mg/L drinking water ⁵¹⁸ 1000–2000 mg/L drinking water ²³⁰ 2000–3000 mg/kg soft feed ²³⁰		
Apramycin (Apralan, Elanco)	—	Aminoglycoside; nephrotoxic; therapeutic levels not achieved in Japanese quail at 50 mg/kg IV ³⁴³ Gamebirds Psittacines, chickens/ <i>Pseudomonas</i>	138
	250–500 mg/L drinking water ⁷² 500 mg powder/L drinking water ^{45,597}		
Arsanilic acid (sodium arsanilate or P-amino-benzenearsonic acid) (Pro-Gen, Vêtoquinol)	—	Poultry/do not use in ducks and geese	139
Azithromycin (Zithromax, Pfizer)	—	Newer-generation macrolide indicated for intracellular infections including <i>Toxoplasma</i> , <i>Plasmodium</i> , <i>Chlamydomphila</i> , and <i>Cryptosporidium</i> Blue and gold macaws/PD; nonintracellular infections Blue and gold macaws/PD; intracellular infections (e.g., <i>Chlamydomphila</i>) Most species including psittacines, passerines/intracellular infections including <i>Mycobacterium</i> ; used with ethambutol and rifabutin (see Appendix 42) Most species/ <i>Mycoplasma</i> ; do not use if hepatic or renal disease; can mix with lactulose (stable refrigerated for 3–4 wk)	
Bacitracin methylene disalicylate (Solutracin 200, A.L. Laboratories; BMD Soluble, Alparma)	—	Ratites/ <i>Clostridium perfringens</i> ; prepare daily Quail/ <i>C. perfringens</i> Quail Ostriches <3 mo of age	
	50–400 mg/L drinking water ^{291,612} 2220 mg/L ⁸³ 55–220 mg/kg feed ³⁹⁶ 100–500 mg/kg feed ⁷²		

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Carbenicillin (Geocillin, Roerig; Pyopen, SmithKline Beecham)	—	Extended-spectrum penicillin effective against gram-negative bacteria, especially <i>Pseudomonas</i> , <i>Proteus</i> ⁵⁴⁶	139
	11–15 mg/kg IV q8h ⁶¹²	Ratites	
	100 mg/kg PO q12h ⁴⁰²	Most species	
	100 mg/kg IM q8h ³⁴	Most species	
	100–200 mg/kg IM, IV q6–12h ^{79,145,236,519,546,611}	Most species including psittacines, passerines, soft bills, pigeons, cranes, raptors	
	250 mg/kg IM q12h ⁵⁰⁹	Raptors	
Cefadroxil (Cefa-Tabs, Fort Dodge)	1058 mg/L drinking water ⁴⁰²	Most species	140
	100 mg/kg IT q24h ⁹⁵	Most species/ <i>Pseudomonas</i> respiratory infections	
Cefazolin (Ancef, SmithKline Beecham)	—	First-generation cephalosporin	140
	20 mg/kg PO q12h ⁶³³	Ratites	
	100 mg/kg PO q12h × 7 days ^{233,538}	Most psittacines, pigeons/14–21 day therapy may be indicated for severe or deep pyodermas	
	25–30 mg/kg IM, IV q8h ⁷⁸	Cranes	
	25–50 mg/kg IM, IV q12h ⁵¹⁹	Most species	
	22–110 mg/kg IM q8–12h ²³⁴	Poultry	
Cefotaxime (Claforan, Hoechst-Roussel)	50–75 mg/kg IM q12h ⁵³⁸	Most species	140
	50–100 mg/kg PO, IM q12h ⁴⁸⁰	Raptors	
	—	Third-generation cephalosporin with broad-spectrum activity for many gram-positive and gram-negative pathogens ⁵⁴⁶ ; penetrates cerebrospinal fluid ⁴	
	25 mg/kg IM q8h ⁶¹³	Ratites/young birds	
	50–100 mg/kg IM q8–12h ⁴⁴⁶	Cranes	
	75–100 mg/kg IM q12h ²⁷⁰	Raptors	
Cefoxitin (Mefoxin, Merck)	75–100 mg/kg IM, IV q4–8h ^{38,145,546,611}	Most species including soft bills, psittacines, passerines	140
	100 mg/kg IM q8–12h ²³³	Pigeons	
	—	Second-generation cephalosporin with a wide range of activity against many gram-positive and gram-negative bacteria	
Ceftazidime (Ceptaz, Fortaz, GlaxoSmithKline; Tazicef, SmithKline)	50–75 mg/kg IM, IV q6–8h ^{145,613}	Most species, including soft bills	141
	50–100 mg/kg IM, IV q6–12h ^{519,611}	Psittacines	
Ceftazidime (Ceptaz, Fortaz, GlaxoSmithKline; Tazicef, SmithKline)	—	Third-generation cephalosporin; broad spectrum; penetrates central nervous system ⁴	141
	50–100 mg/kg IM, IV q4–8h ^{177,542}	Most species	

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Ceftiofur (Naxcel, Pharmacia & Upjohn)	—	Broad-spectrum third-generation cephalosporin with activity against <i>Pasteurella</i> , <i>Escherichia coli</i> , <i>Streptococcus</i> , <i>Staphylococcus</i> , and <i>Salmonella</i> ⁴ Ratites Orange-winged Amazon parrots/PD Cockatiels/PD; higher doses may be required for resistant infections Ostrich chicks Most species, including psittacines and passerines Chickens (chicks)/PD; treatment of early mortality associated with <i>E. coli</i> Turkeys (poults)/PD; treatment of early mortality associated with <i>E. coli</i> Turkeys	
	10–20 mg/kg IM q12h ^{1,633} 10 mg/kg IM q8–12h ⁶⁰² 10 mg/kg IM q4h ⁶⁰² 50 mg/kg IM q12h ¹ 50–100 mg/kg q4–8h ^{145,546,611} 0.16 mg/chick SC q24h ⁶⁰² 2.8–5.8 mg/kg SC q24h ⁶⁰² 0.17–0.50 mg/poult SC q24h ⁶⁰²		
Ceftriaxone (Rocephin, Roche)	—	Third-generation cephalosporin; effective against gram-positive and gram-negative bacteria including some activity against <i>Pseudomonas</i> ⁵⁴⁶ Most species Chickens/PD	
	75–100 mg/kg IM q4–8h ^{173,546,611} 100 mg/kg IM q4h ³⁰⁸		
Cephalexin (Keflex, Dista)	—	First-generation cephalosporin; active against many gram-positive and gram-negative bacteria, including <i>E. coli</i> and <i>Proteus</i> , but not <i>Pseudomonas</i> ; useful for <i>Staphylococcus dermatitis</i> ⁴ Ratites (excluding emus) Pigeons, emus, cranes, raptors, psittacines >500 g/dose psittacines q6h	141
	15–22 mg/kg PO q8h ⁶¹² 35–50 mg/kg PO, IM q6–8h ^{70,106,270,446} 35–50 mg/kg IM q2–3h ^{70,106} 40–100 mg/kg PO, IM q6–8h ^{34,44,145,546,611} 50 mg/kg PO q6h × 3–5 days ^{72,415} 55–110 mg/kg PO q12h ²³⁴ 100 mg/kg PO q8–12h ^{233,316} 100 mg/kg PO q4–6h ⁷⁰	Quail, ducks/PD, psittacines <500 g Most species, including raptors psittacines, passerines Raptors, pigeons Poultry/ <i>Mycoplasma</i> , <i>Haemophilus</i> Most species, including pigeons/14–21 day therapy may be indicated for severe or deep pyodermas Pigeons, emus, cranes/PD	142
Cephalothin (Keflin, Lilly)	—	First-generation cephalosporin Ratites (excluding emus) Raptors Most species, including psittacines, ratites Pigeons, emus, cranes/PD Passerines Quail, ducks/PD	
	30–40 mg/kg IM, IV q6h ⁶¹² 100 mg/kg IM q8–12h ²⁷⁰ 100 mg/kg IM, IV q6–8h ^{95,612} 100 mg/kg IM q6h ⁷⁰ 100 mg/kg IM, IV q2–6h ¹⁴⁵ 100 mg/kg IM q2–3h ⁷⁰		
Cephradine (Cephadrine, Biocraft)	—	First-generation cephalosporin Most species/14–21 day therapy may be indicated for severe or deep pyodermas Pigeons, emus, cranes	
	35–50 mg/kg PO q4–6h ⁵¹⁸ 100 mg/kg PO q4–6h ⁵¹⁸		

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Chloramphenicol palmitate (oral suspension)	—	Not for use in food animals ²⁴⁵ ; wear gloves; bone marrow suppression (irreversible aplastic anemia in humans); potential nephrotoxicity; bacteriostatic activity ⁴⁷³ ; mainly excreted after biotransformation; because large differences in pharmacokinetics exist between birds and mammals, and even between avian species, extrapolation between species is ill advised ¹⁴⁹	
	25 mg/kg PO q8h × 5 days ⁷² 30–50 mg/kg PO q6–8h ^{546,610,611} 35–50 mg/kg PO q8h × 3 days ⁶¹²	Pigeons Psittacines, including budgerigars Ratites	142
	50 mg/kg PO q6–12h ^{11,270,520} 50–100 mg/kg PO q6–12h ^{34,145} 250 mg/kg PO q6h ²³⁴ 100–200 mg/L drinking water ⁵¹⁹	Raptors, galliformes (e.g., turkeys) Most species, including passerines Pigeons Canaries	143
Chloramphenicol succinate (Chloramphenicol Succinate, Fort Dodge, Parke-Davis)	22 mg/kg IM, IV q3h ¹³² 30 mg/kg IM q8h × 3–5 days ¹⁹¹ 35–50 mg/kg SC, IM, IV q8h × 3 days ⁶¹² 50 mg/kg IM q6h ⁸⁸ 50 mg/kg IM q8–12h ¹⁴⁵ 50 mg/kg IM q24h ⁸⁸ 50 mg/kg IM, IV q6–12h ^{88,145,546} 50–80 mg/kg IM q12–24h ¹⁴⁵ 60–100 mg/kg IM q8h ²³⁶ 79 mg/kg IM q12h ⁸⁸ 100 mg/kg SC q8h ⁴⁴⁶ 100 mg/kg IM q6h ¹⁴⁵ 200 mg/kg IM q12h × 5 days ²⁷⁸	Ducks (PD), raptors Raptors Ratites Macaws, conures (PD) Passerines Peafowl, eagles (PD) Most species, including budgerigars, passerines, pigeons, raptors, chickens, turkeys, geese (PD) ⁸⁸ ; ducks Passerines Pigeons Turkeys/PD Cranes Passerines Budgerigars/PD	
Chlorhexidine	2.6–7.9 ml of 2% solution/L drinking water ^{520,591} 7.9 ml/L water ⁶¹²	Most species/bacterial infection; topical application may be fatal to nun and parrot finches ⁵¹⁹ Ratites/egg disinfectant spray at 104–108° F (40–42° C)	
Chlorine (Na hypochlorite)	5 mg/L drinking water ⁵³⁸	Water disinfectant; 0.1 ml of 5.25% bleach/L approximates this concentration	

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Chlortetracycline (Aureomycin Soluble Powder, Cyanamid)	—	Broad-spectrum activity against a wide range of gram-positive and gram-negative bacteria; flock treatment of <i>Chlamydomphila</i> although doxycycline is preferred ⁵⁴⁶ ; outdated tetracycline is nephrotoxic ²⁰⁰	143
	6–10 mg/kg IM q24h ²⁵³	Raptors	144
	15–20 mg/kg PO q8h ⁶¹²	Ratites	
	40–50 mg/kg PO q8h (w/grit) or q12h (w/o grit) ¹⁴³	Pigeons/PD	
	100 mg/kg PO q6h ¹⁰⁶	Psittacines	
	40–120 mg/L drinking water ⁷²	Galliformes (game birds)	
	250 mg/kg PO q24h ²⁵³	Raptors	
	130–400 mg/L drinking water ^{233,546,608}	Pigeons	
	100 mg/kg feed ⁶⁰⁸	Pigeons/ <i>Salmonella</i>	
	200–600 mg/kg feed ⁷²	Galliformes	
	300–400 mg/kg feed ⁸³	Waterfowl/colibacillosis, <i>Chlamydomphila</i> , <i>Salmonella</i>	
	500 mg/kg feed ¹⁴⁴	Budgedrigars/ <i>Chlamydomphila</i>	
	500 mg/L drinking water or nectar ^{94,95}	Most species/prepare fresh q8–12h	
	1000 mg/kg feed	Waterfowl ⁴⁴	
	1000–1500 mg/L drinking water ^{106,142}	Canaries, psittacines/prophylaxis against <i>Chlamydomphila</i>	
	1000–2000 mg/kg soft mixed feed × 45 days ^{45,142,143}	Most psittacines, canaries	
	2500 mg/kg feed ⁶⁶¹ and 2500 mg/L drinking water	Chickens, turkeys/PD; simultaneous medication of feed and water required to reach therapeutic level ^{54,666}	
	5000 mg/L drinking water × 45 days ¹⁰⁶	Psittacines/ <i>Chlamydomphila</i>	
	5000 mg/kg soft feed × 45 days ¹⁰⁶	Psittacines/ <i>Chlamydomphila</i>	
	0.5% pellets × 30–45 days ^{34,94,95,141}	Small psittacines/reduce calcium content of diet to 0.7%	
	1% pellets × 30–45 days ^{141,174,181}	Large psittacines/reduce calcium content of diet to 0.7%	
Ciprofloxacin (Cipro, Bayer)	—	Broad-spectrum quinolone; not approved for use in food-producing birds in the United States ¹⁹⁰	144
	2 mg/kg IV ⁴³¹	Chicks/no toxic effects observed	
	3–6 mg/kg PO q12h ⁶¹²	Ratites	145
	5 mg/kg/day PO × 5 days ²⁰⁷	Chickens/PD	
	5–20 mg/kg PO q12h × 5–7 days ⁵³⁹	Pigeons	
	10 mg/kg PO q12h × 7 days ²	Ostrich chicks	
	10–20 mg/kg PO q12h ^{155,270}	Raptors, chickens	
	15–20 mg/kg PO, IM q12h ^{34,145,610,611}	Most species including psittacines, passerines	
	20–40 mg/kg PO, IV q12h ^{396,519}	Most species including psittacines, canaries, raptors	
	50 mg/kg PO q12h ²⁷⁷	Raptors/PD	
	80 mg/kg PO q24h ⁶²⁰	Most species/ <i>Mycobacterium</i> ; use in combination with other agents (see Appendix 42)	
	250 mg/L drinking water × 5–10 days ⁵³⁹	Pigeons	

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Clarithromycin (Biaxin, Abbott)	—	Broad-spectrum new-generation macrolide Most species/ <i>Mycobacterium</i> ; allometrically scaled; frequently used in combination with other drugs for mycobacteriosis (see Appendix 42)	
	85 mg/kg PO q24h ⁵⁴¹		
Clindamycin (Antirobe, Upjohn)	—	Lincosamide; indicated for bone, joint, and tendon sheath infections; may be used for up to 12 wk without ill effects ⁵⁴⁶ ; monitor kidney and liver with long-term use as well as for yeast overgrowth	
	5.5 mg/kg PO q8h ⁴¹⁵	Ostriches	
	12.5 mg/kg PO q12h ²³¹	Great horned owls/skin grafts; given in conjunction with enrofloxacin	
	25 mg/kg PO q8h ¹⁷⁴	Psittacines, raptors	
	50 mg/kg PO q8–12h ¹⁷⁷	Most species; 7–10 day course recommended for raptors with osteomyelitis ⁴⁴	
	100 mg/kg PO q24h × 3–5 days ^{145,174,270,520,546,611}	Most species, including psittacines, passerines, raptors, pigeons, quail/ <i>Clostridium</i>	
	100 mg/kg PO q12h ⁴⁷¹ × 7 days	Psittacines	145
	150 mg/kg PO q24h ²²³	Pigeons, raptors/osteomyelitis	
	200 mg/L drinking water ¹¹³	Pigeons	146
Clofazimine (Lamprone, Ciba Geneva)	1–5 mg/kg PO q24h × 3–12 mo ^{44,45,546}	Psittacines, raptors/ <i>Mycobacterium</i> ; use in combination with other agents (see Appendix 42)	
	6 mg/kg PO q12h ^{541,620}	Most species/ <i>Mycobacterium</i> ; use in combination with other agents (see Appendix 42)	
	6–12 mg/kg PO q24h ¹⁴⁵	Passerines/ <i>Mycobacterium</i> (see Appendix 42)	
Cloxacillin (Cloxapen, SmithKline Beecham; Tegopen, Bristol; Orbenin, Beecham)	—	Penicillin effective against many gram-positive organisms; recommended in the treatment of pododermatitis ⁵⁴⁶	
	100–200 mg/kg IM q24h ⁴¹⁵	Most species	
	250 mg/kg PO q24h ³⁸⁸	Most species	
	250 mg/kg PO q12h × 7–10 days ⁴⁴	Raptors	
Cycloserine (Seromycin, Lilly)	5 mg/kg PO q12–24h × 3–12 mo ^{44,546}	Raptors/ <i>Mycobacterium</i> ; use in combination with other agents (see Appendix 42)	
Danofloxacin mesylate (A180, Pfizer)	—	Fluoroquinolone; not approved for use in food-producing birds in the United States ¹⁹⁰	
	5 mg/kg PO, IM IV ^{155,405,597}	Hyacinth macaws, chickens/PD (chickens); higher therapeutic efficacy of water medication for enrofloxacin compared with danofloxacin can be expected when given at 5 mg/kg ³²²	
	50 mg/L in drinking water × 3 days ^{408,519,598}	Chicken chicks/ <i>Mycoplasma</i>	

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Doxycycline (Vibramycin, Pfizer)	—	Drug of choice for <i>Chlamydophila</i> , <i>Mycoplasma</i> ; products or foods containing Al, Ca, Mg, and Fe reduce or alter absorption although doxycycline has a relatively low affinity for calcium binding ¹⁵¹ ; outdated tetracycline is nephrotoxic ²⁰⁰ ; 12.5–25 mg/kg PO q12–24h resulted in elevations in AST and serum bile acids as well as hepatocellular damage in lorikeets ⁶⁶³	146
	2.0–3.5 mg/kg PO q12h ⁶¹² 7.5–8.0 mg/kg PO q12–24h ^{140,519} 8–25 mg/kg PO q12h ⁸³ 10–20 mg/kg PO q24h × 3–5 days ⁷² 25 mg/kg (w/grit) PO q12h ^{143,145,159} 25 mg/kg PO q12h ³⁰² 25–50 mg/kg PO q12–24h ^{143,174,270,610,611} 40 mg/kg PO q24h ¹³¹ 50 mg/kg PO q12h ⁴⁴ 100 mg/L drinking water ¹⁵⁸ 130 mg/L drinking water ¹⁰⁶ 200 mg/L drinking water ¹⁵⁹ 250 mg/L drinking water ¹⁴² 265–525 mg/L drinking water ²³⁴ 280 mg/L drinking water ⁴⁸⁴ 500 mg/L drinking water ^{106,131} 500 mg/L drinking water ⁴⁵⁸ 800 mg/L drinking water (mix the contents of 16–100 mg capsules with 2 L water; make fresh daily) ¹⁸⁴	Ratites Passerines, nectar feeders, pigeons/PD; administer without grit ¹⁴² Waterfowl Pigeons Pigeons/PD Psittacines, raptors/some gramnegative bacterial infections and possibly <i>Leucocytozoon</i> Most species, including parrots (African grey parrots, Amazon parrots, cockatoos, macaws) and pigeons ²³⁶ /may cause regurgitation; use low end of dose range for macaws, cockatoos ¹¹⁹ Pigeons/PD; <i>S. bovis</i> Waterfowl Chickens/PD Psittacines Pigeons Canaries Poultry/ <i>Mycoplasma</i> , <i>Haemophilus</i> ; can use in combination with tylosin Cockatiels; see Appendix 38 for recipe Psittacines, pigeons/PD; <i>S. bovis</i> Fruit doves/PD; erratic drug concentrations (although most birds reached or exceeded therapeutic drug levels, some birds did not) African grey parrots, Goffin's cockatoos/PD ¹⁸⁴ ; protect solution from exposure to light	147
	250–300 mg/kg seed ^{44,175} 500 mg/kg feed wet weight seeds ⁴⁸⁴ 1000 mg/kg feed ^{142,143,487}	Waterfowl, budgerigars (PD) Cockatiels/PD; see Appendix 35 for recipe Large psittacines on dehulled seed (PD); macaws on corn (PD); canaries, large psittacines on soft feed (10 mg/ml syrup mixed into 29% kidney beans, 29% canned corn, 29% cooked rice, 13% dry oatmeal cereal)	148

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Doxycycline (Vibravenös, Pfizer)	—	Not available in United States without written permission by Food and Drug Administration Psittacines
	25–50 mg/kg IM q5–7d × 5–7 treatments ^{542,610}	
	60–100 mg/kg SC, IM q5–7d ¹⁴²	Psittacines, pigeons/PD
	75 mg/kg IM q7d × 4–6 wk ^{38,44}	Macaws, waterfowl
	75–100 mg/kg IM q5–7d × 4–6 wk ^{38,542,610}	Psittacines, including macaws, budgerigars
	100 mg/kg SC, IM q5–7d × 7 doses ²²¹	Houbara bustards/PD; <i>Chlamydophila</i>
Doxycycline (Pharmacist-compounded micronized doxycycline hyclate)	75–100 mg/kg IM q7d ⁵⁴²	Cockatoos/anecdotal reports of sudden death with compounded product; inadequate drug levels achieved in cockatiels at 100 mg/kg IM q10d ⁴⁸⁴
Doxycycline hyclate (Vibramycin injection, Pfizer)	—	Cardiovascular collapse associated with the propylene glycol carrier can occur after rapid IV injection ²⁰⁰
	25–50 mg/kg slow bolus IV q24h × 3 days ⁵⁴²	Psittacines
	75–100 mg/kg IM, SC q5–7d ¹⁴⁰	Pigeons/PD
Doxycycline (Doxirobe Gel, Pharmacia)	Topical ⁵⁷⁶	Most species/apply to beak or pododermatitis lesions; use in conjunction with debridement; antibiotic is released for 28 days

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Enrofloxacin (Baytril, Bayer)	—	Broad-spectrum quinolone ¹⁹⁰ ; compounds containing Ca, Al, Fe, Mg, Zn interfere with absorption	148
		Administration may be associated with emesis ⁵⁴⁶ ; given orally, the IM formulation produces therapeutic plasma concentration ²⁷⁰ ; IM formulation is extremely alkaline (painful) and should not be given repeatedly; in general, avoid IV use in birds	149
		Joint deformities reported in squab chondrocytes with 200–800 mg/L drinking water ³³¹ ; however, enrofloxacin has been commonly used at the recommended dosages without reports of adverse effects ^{178,519} ; no detected effect on cartilage in day-old chicks ⁴⁶⁸	
		Administration of the total daily dose to chickens over 2–4 hr (pulse dosing) has been recommended by some ⁵⁸⁰	
	1.5–2.5 mg/kg PO, SC q12h ⁶¹²	Ratites	
	2.2 mg/kg IV q12h ²⁵⁵	Emus/PD; based on results of the study, enrofloxacin could be administered parenterally q12h	
	5 mg/kg SC, IM q12h ⁶¹⁰	Cockatiels	
	5 mg/kg PO, IM q12–24h ⁶¹⁰	African grey parrots	
	5 mg/kg IM q12h × 2 days ⁶¹²	Ratites	
	5 mg/kg/day PO × 5 days ²⁰⁷	Chickens/PD; accumulates in eggs	
	5–10 mg/kg SC, IM q24h ^{142,144}	African grey parrots	
	5–10 mg/kg PO q8h ⁴⁰²	Passerines, pigeons (PD)	
	5–15 mg/kg PO, SC, IM q12h ^{236,270,542,546,611}	Raptors, psittacines, pigeons/drug of choice for <i>Salmonella typhimurium</i>	
	5–20 mg/kg PO q12–24h × 5–10 days ^{72,610}	Pigeons	
	10 mg/kg PO q12h ⁷⁹	Cockatiels	
	10 mg/kg PO q12h × 4 days ¹⁷	Chickens/PD; high efficacy for intestinal salmonellosis	
	10–15 mg/kg PO, IM q12h × 5–7 days ^{45,546}	Raptors, waterfowl including Muscovy, Pekin ducklings/ <i>Riemerella (Pasteurella)</i>	149
	10–20 mg/kg PO q24h ^{142,145}	Passerines, psittacines, pigeons (PD)	150
	15 mg/kg PO q24h ⁴⁷¹	Psittacines	
	15 mg/kg PO q12h ^{1,367}	Ostrich chicks, pigeons (administration to adult birds led to therapeutic levels in crop milk)	
	15 mg/kg PO, IM, IV q12h ²³⁸	Raptors/PD; IV administration in owls may result in weakness, tachycardia, vasoconstriction	
	15 mg/kg PO, SC q12h ¹⁷⁷	Most species	
	15–30 mg/kg PO, IM q12h ¹⁸⁰	African grey parrots/PD	
	20 mg/kg PO, SC, IM q12h ^{236,546}	Pigeons/administer parenterally, followed by oral treatment	
	20–30 mg/kg PO q12–24h ¹⁵⁹	Pigeons	
	25 mg/kg PO, SC q24h ¹⁷⁷	Experimental	

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	<p>30 mg/kg PO, IM q24h⁶¹¹ 45 mg/kg PO q24h²³⁶ 50 mg/kg × 4 hr (day 1, AM), then 25 mg/kg × 4 hr/day × 4 days⁶¹⁴ 25–50 mg/L drinking water⁶¹ 26 mg/L drinking water⁸³ 50 mg/L drinking water^{254,316} 50–100 mg/L drinking water⁷² 100–200 mg/L drinking water^{142,159,539,546} 200 mg/L drinking water¹⁸³ 190–750 mg/L drinking water¹⁷⁸ 200 mg/L drinking water¹⁴³</p>	<p>Psittacines Pigeons Muscovy, Pekin ducklings/<i>Riemerella (Pasteurella)</i> Cranes (sandhill)/did not provide sufficient plasma levels Galliformes Chickens, turkeys/PD Gamebirds Psittacines, pigeons/PD; may need up to 300 mg/L to prevent recurrence of infection in pigeons⁵⁴⁶ Psittacines/PD; maintains plasma concentrations adequate only for highly susceptible bacteria African grey parrots/PD Canaries</p>	150
	<p>500 mg/L drinking water³⁶¹ 200 mg/kg soft feed¹⁴³ 250 mg/kg feed¹⁴² 250–1000 mg/kg feed q24h^{144,610} 500 mg/kg feed³⁶¹ 1000 mg/kg feed³⁶¹ 0.2 mg/ml saline, flush q24h × 10 days⁴⁴</p>	<p>Psittacines Canaries Budgerigars/PD Psittacines, passerines Psittacines, including Patagonian conures/PD; mix into steamed corn diet Senegal parrots/PD; mix into steamed corn diet Raptors/nasal flush</p>	151
Erythromycin (Erythrocin, Abbott; Erymycin 100, Bimeda)	—	<p>Macrolide; gram-positive spectrum; some activity against <i>Mycoplasma</i>⁵⁴⁶; IM injection may cause severe muscle necrosis²⁴⁵ Ratites Passerines Psittacines Passerines Poultry/<i>Mycoplasma</i>, <i>Haemophilus</i> Most species Pigeons/PD; <i>S. bovis</i> Pigeons/PD; low plasma levels but higher lung and trachea levels Canaries Pigeons Chicks/PD Most species, including canaries Psittacines Psittacines Pigeons/PD; <i>S. bovis</i>; plasma levels low; one study reported that lung and trachea levels were subtherapeutic</p>	151
	<p>5–10 mg/kg PO q8h⁶¹² 10–20 mg/kg IM q24h¹⁴⁴ 10–20 mg/kg PO q12h⁵⁴⁶ 50–100 mg/kg PO q8–12h¹⁴⁴ 55–110 mg/kg PO q12h²³⁴ 60 mg/kg PO q12h²⁶⁴ 71 mg/kg PO q24h¹³¹ 100 mg/kg PO⁶²¹ 125 mg/L drinking water¹⁴³ 125 mg/kg PO q8h²³³ 102 mg/L drinking water¹³⁵ 132 mg/L drinking water (10 days on, 5 days off, 10 days on)^{95,143} 250–500 mg/L drinking water × 3–5 days¹⁰⁶ 525–800 mg/L drinking water²³³ 1000 mg/L drinking water^{131,621}</p>	<p>1500 mg/L drinking water⁵⁴⁶ 200 mg/kg soft feed¹⁴³</p>	152

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Esofloxacin (under development)	2.5–20.0 mg/kg ⁵⁹⁷	Poultry/antibacterial; antimycoplasmal	
Ethambutol (Myambutol, Lederle)	— 10 mg/kg PO q12h ³⁸ 15–20 mg/kg PO q12h × 3–12 mo ^{44,45} 15–30 mg/kg PO q12–24h ¹⁴⁵ 30 mg/kg PO q24h ⁵⁴¹	Most species/ <i>Mycobacterium</i> ; use in combination with other agents (see Appendix 42) Most species Psittacines, raptors/ <i>Mycobacterium</i> Passerines/ <i>Mycobacterium</i> Most species/ <i>Mycobacterium</i>	
Flucloxacillin (Flumox, Rolab; Flucloxin, Athlone)	— 125 mg/kg PO q12h ²³²	Penicillin; active against many gram-positive bacteria; not available in the United States Raptors/musculoskeletal surgery	
Flumequine (Biocik, Amacol)	— 30 mg/kg PO, IM q8–12h ^{140,145}	Quinolone; not available in the United States; may cause emesis Passerines, pigeons (PD)	
Furazolidone (NF180, Hess and Clark)	— 15–20 mg/kg PO q24h ¹⁴⁵ 100–200 mg/L drinking water ⁵¹⁹ 200 mg/kg soft food ⁵¹⁹ 908 mg/kg feed ⁶⁰⁸ 220–440 mg/kg feed ⁸³	Nitrofur derivative; prohibited in food-producing birds because of its carcinogenic properties; therapeutic action is confined to the gastrointestinal tract Passerines Canaries Canaries Pigeons/ <i>Salmonella</i> Waterfowl/ <i>Salmonella</i>	
Gentamicin (Garamycin, Schering)	— 1–2 mg/kg IM q8h ⁶¹²	Aminoglycoside; not generally recommended; narrow margin of safety; nephrotoxic ^{12,47,48} ; bird should be well hydrated; avoid doses higher than 2.5–5.0 mg/kg q8–12h ^{47,182} Ratites (excluding emus)/use only as last resort	152
	2.5 mg/kg IM q8h ⁴⁷ 3–10 mg/kg IM q6–12h ¹⁴⁵ 5 mg/kg IM q8h ^{69,118,291} 5 mg/kg IM q12h ¹⁸² 5–10 mg/kg IM q8–12h ⁵⁰⁰ 5–10 mg/kg IM q4h ^{69,544} 10 mg/kg IM q6h ^{69,118} 40 mg/kg PO q8–24h ¹⁴⁵ 2–3 drops ophthalmic solution intranasal q8h ⁶¹⁰	Raptors/PD Passerines Pheasants, emus (PD), cranes (PD) Ostriches, emus/PD; rapidly eliminated; small volume of distribution Cockatiels/PD Pigeons/PD; <i>Salmonella</i> Quail/PD Passerines/intestinal infections Most species	153
Isoniazid (Isoniazid Tablets, Duramed)	— 5–15 mg/kg PO q12h ^{144,518,610} 30 mg/kg PO q24h ⁶²⁰	Most species/ <i>Mycobacterium</i> ; should be used in combination with other drugs (see Appendix 42); <i>Mycobacterium avium</i> often develops resistance Most species, including passerines Most species	
Kanamycin (Kantrim, Fort Dodge)	— 10–20 mg/kg IM q12h ¹¹ 13–65 mg/L drinking water × 3–5 days ^{11,67}	Aminoglycoside Most species, including passerines ¹⁴⁴ /enteric infections Most species/make fresh daily	

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Lincomycin (Lincocin, Upjohn)	—	<p>Gram-positive spectrum indicated for pododermatitis, chronic dermatitis, and mycoplasmosis⁵⁴⁶</p> <p>Raptors/musculoskeletal surgical repair</p> <p>Passerines</p> <p>Psittacines, raptors/pododermatitis, osteomyelitis</p> <p>Raptors</p> <p>Psittacines</p> <p>Pigeons</p> <p>Canaries</p> <p>Waterfowl/<i>Pasteurella</i>, mycoplasmal tenosynovitis</p>	153
<p>25–50 mg/kg PO q12h²³²</p> <p>35–50 mg/kg PO q12–24h¹⁴⁵</p> <p>50–75 mg/kg PO, IM q12h × 7–10 days^{45,107,546}</p> <p>100 mg/kg PO q24h⁵¹⁸</p> <p>100 mg/kg IM q12h⁴⁵</p> <p>35–50 mg/pigeon q24h × 7–14 days³⁹⁵</p> <p>100–200 mg/L drinking water¹⁴³</p> <p>2000 mg/L drinking water × 5–7 days⁴⁴</p>	—	<p>0.25–0.5 ml intra-articular q24h × 7–10 days⁵⁴⁶</p> <p>Topical</p> <p>Raptors</p> <p>Mixture of lincomycin (50 mg/ml) and tobramycin (10 mg/ml) was used to flush the flexor tendon sheath²³²</p>	154
Lincomycin/spectinomycin (LS-50 Water Soluble, Linco-Spectin 100 Soluble Powder, Upjohn)	—	<p>Effective against gram-positive bacteria, <i>Mycoplasma</i></p> <p>Most species</p> <p>Turkeys/PD; <i>Mycoplasma</i> airsacculitis</p> <p>Waterfowl</p> <p>Most species/using soluble powder, 16.7 g lincomycin and 33.3 g spectinomycin per 2.55 oz powder</p> <p>Chicken chicks/PD; may prevent <i>E. coli</i> and <i>Staphylococcus aureus</i> infections; injectable form not available in United States</p>	
Marbofloxacin (Marbocyl, Univet; Zeniquin, Pfizer)	—	<p>Fluoroquinolone; not approved for use in food-producing birds in the United States¹⁹⁰; less likely to cause emesis compared with enrofloxacin⁵⁴⁶; use with caution in juvenile birds²⁵³; may adversely affect molt¹⁰⁷</p> <p>Broiler chickens/PD</p> <p>Blue and gold macaws/PD</p> <p>Most species</p> <p>Raptors, bustards</p>	
Meropenem (Merrem, Abbott)	—	<p>Broad-spectrum carbapenem antibiotic penetrates well into most body fluids and tissues, including cerebrospinal fluid</p> <p>Pigeons/PD</p>	
<p>2 mg/kg PO q24h¹⁸</p> <p>2.5–5.0 mg/kg PO 24h^{79,81}</p> <p>5 mg/kg PO q24h¹⁰⁵</p> <p>10–15 mg/kg PO, IM q12h × 5–7 days^{44,107,546}</p> <p>175 mg/kg IM q24h⁵⁵⁶</p>	—		

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Metronidazole (Flagyl, Searle)	—	Active against most anaerobes; see antiprotozoal dosages	
	10 mg/kg IM q24h × 2 days ⁶¹¹	Psittacines	
	10–30 mg/kg PO q12h × 10 days ⁶¹¹	Psittacines	154
	50 mg/kg PO q24h × 5–7 days ^{38,44,471}	Most species, including raptors, psittacines/anaerobes	155
	50 mg/kg PO q12h × 30 days ⁵³⁸	Amazon parrots, cockatoos/anaerobic and hemorrhagic enteritis	
Minocycline (Minocin, Lederle)	—	Products or foods containing Ca, Al, Mg, Fe reduce or alter absorption; outdated tetracycline is nephrotoxic	
	15 mg/kg PO q12h ⁵⁰²	Raptors/some anaerobes	
	5000 mg/kg feed ¹¹	Parakeets/use as antibiotic impregnated millet	
Miporamicin	100 mg/kg feed × 5 days ⁵⁹⁷	Poultry/macrolide; under development; make preparation fresh daily	
Neomycin (Neomycin Sulphate, A.G. Scientific; Neomycin 325 Soluble Powder, AgriLabs; Neomix 325 Soluble Powder, Pharmacia)	—	Aminoglycoside/not absorbed from gastrointestinal tract	
	5–10 mg/kg IM q12h ²⁵³	Raptors/toxic if overdosed	
	10 mg/kg PO q24h ¹⁴⁵	Passerines	
	10 mg/kg PO q8–12h ⁶⁷	Most species	
	80–100 mg/L drinking water ⁵¹⁹	Canaries	
	80–264 mg/L drinking water ⁸³	Waterfowl	
	126 mg/L drinking water ⁷²	Galliformes	
	70–220 mg/kg feed × 14–21 days ^{49,83}	Waterfowl, galliformes/ <i>Clostridium</i> , necrotizing enteritis	
	Topical q6–12h ⁵¹⁹	Most species/superficial wounds; cover with bandage; may be absorbed systemically and may cause ototoxicity and nephrotoxicity	
Nitrofurantoin (Nitrofurantoin, Pharm Chemical)	—	Systemic and topical use banned in poultry used for human consumption because of its carcinogenic properties ¹⁸⁹	
	26 mg/L drinking water × 5–7 days ⁸³	Galliformes	
	50–200 mg/kg feed × 5–7 days ⁸³	Galliformes/ <i>Clostridium</i> , <i>Salmonella</i>	
Nitrofurazone (NFZ 9.2, Hess & Clark; Nitrofurazone, Aspen)	—	Systemic use banned in food-producing birds because of its carcinogenic properties ¹⁸⁹ ; may be hepatotoxic; avoid use or reduce dosage in hot weather; do not use in finches or pigeons ^{362,539}	155
	0.3 mg/L drinking water × 7 days ⁵¹⁸	Lories, mynahs/do not put in lory nectar	156
	0.6 mg/L drinking water × 7–10 days ⁴⁰²	Most species	

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Norfloxacin (Noroxin, Merck; Vettriflox 20% Oral Solution, Lavet Ltd)	—	Fluoroquinolone; not approved for use in food-producing birds in the United States ¹⁹⁰ ; administration of the total daily dose to chickens over 2–4 hr (pulse dosing) has been recommended ⁵⁸⁰ Ratites Chickens/PD Chickens, geese/PD Turkeys/PD Turkeys/PD; once-per-day pulse dosing was more efficacious than continuous dosing in the water Chickens Chickens/PD Chickens
	3–5 mg/kg PO q12h ⁶¹² 8 mg/kg PO q24h ¹⁹ 10 mg/kg PO q24h ³³⁷ 10 mg/kg PO q6–8h ³³⁷ 15 mg/kg in water over 2–4 hr ⁵⁵² 20–40 mg/kg PO q24h × 5 days ³⁶⁸ 100 mg/L drinking water × 5 days ⁵⁵² 175 mg/L drinking water × 5 days ⁵²⁷	
Novobiocin sodium (Albamix, Pharmacia & Upjohn)	15–30 mg/kg PO q24h ⁵⁹⁷ 220–385 mg/kg feed ^{396,598}	Poultry Poultry, waterfowl
Oleandomycin (Amimycin, Matromycin, Romicil, Pfizer)	— 25 mg/kg IM q24h ¹⁴⁵ 50 mg/kg PO q24h ¹⁴⁵	Macrolide; not available in the United States Passerines Passerines
Ormetoprim-sulfadimethoxine (Primor, Pfizer; Rofenaid 40, Hoffman-La Roche)	— 60 mg/kg PO q12h ²³⁶ 475–951 mg/L drinking water × 7–10 days ²³⁶ 200–800 mg/kg feed ⁸³	See sulfonamides Pigeons Pigeons Waterfowl/colibacillosis
Oxytetracycline (Liquamycin, LA-200, Terramycin Soluble Powder, Pfizer)	—	IM administration may cause muscle irritation or necrosis; may be useful in treating <i>Chlamydothila</i> , fowl cholera ⁶⁴⁰ ; products or foods containing Al, Ca, Mg, Fe reduce or alter absorption; outdated tetracycline is nephrotoxic ²⁰⁰

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	<p>5 mg/kg SC, IM q12–24h⁵⁰</p> <p>5 mg/kg IM q12h⁶³³</p> <p>10 mg/kg IM q3d⁶¹²</p> <p>15–50 mg/kg SC, IM q12–24h¹⁴⁵</p> <p>16 mg/kg IM q24h⁶⁰¹</p> <p>23 mg/kg IV q6–8h⁶⁰¹</p> <p>25–50 mg/kg PO, IM q8h × 5–7 days⁴⁴</p> <p>43 mg/kg IM q24h⁶⁰¹</p> <p>48 mg/kg IM q48h²⁷⁰</p> <p>50 mg/kg IM q24h × 5–7 days⁵⁴⁶</p> <p>50 mg/kg PO q6–8h²³³</p> <p>50–75 mg/kg SC¹⁷⁴</p> <p>50–100 mg/kg SC, IM q2–3d^{145,179}</p> <p>50–200 mg/kg IM q3–5d⁵⁴⁶</p> <p>58 mg/kg IM q24h⁶⁰¹</p> <p>80 mg/kg IM q48h⁵⁴⁶</p> <p>130–400 mg/L drinking water^{49,233}</p> <p>200 mg/kg IM q24h^{38,44}</p> <p>300 mg/kg soft feed × 5–14 days¹⁰⁶</p> <p>650–2000 mg/L drinking water × 5–14 days¹⁰⁶</p> <p>2500 mg/L drinking water and 2500 mg/kg feed^{546,661}</p>	<p>Chicken chicks/PD</p> <p>Ratites</p> <p>Ratites</p> <p>Passerines</p> <p>Great horned owls/PD</p> <p>Pheasants/PD</p> <p>Raptors</p> <p>Pheasants/PD</p> <p>Owls</p> <p>Psittacines</p> <p>Pigeons</p> <p>Goffin's cockatoos, blue and gold macaws</p> <p>Cockatoos (PD), passerines</p> <p>Raptors</p> <p>Amazon parrots/PD</p> <p>Pigeons <400 g</p> <p>Pigeons</p> <p>Most species including waterfowl/<i>Pasteurella</i></p> <p>Psittacines</p> <p>Psittacines</p> <p>Chickens (PD), turkeys (PD), waterfowl/simultaneous medication of feed and water required to reach therapeutic level</p>	157
Penicillin	50,000 IU/kg IM ⁸³	Waterfowl/ <i>Erysipelas</i> , new duck disease	
Penicillin benzathine/procaine (Benza-Pen, SmithKline)	—	Anecdotal reports suggest procaine penicillin should not be used in birds <1 kg BW because of possible toxic effects ⁶¹⁰	
	200 mg/kg IM q24h ³⁸	Most species	157
Penicillin G (potassium; Potassium Penicillin G, Apothecon)	6 mg/kg IV ⁸⁹	Ostriches, emus/PD; rapidly eliminated; small volume of distribution	158
Penicillin procaine (Penicillin G Procaine, SmithKline)	—	Anecdotal reports suggest procaine penicillin should not be used in birds <1 kg BW; adverse reactions (possible toxic effects) described in finches, canaries, budgerigars, cockatiels ^{173,610}	
	100 mg/kg IM q24–48h ²⁶⁰	Turkeys/PD	

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Piperacillin (Piperacil, Lederle)	—	Extended-spectrum penicillin with broad-spectrum activity against many gram-positive and gram-negative aerobic and anaerobic organisms including <i>Pseudomonas</i> ⁵⁴⁶ ; presently not commercially available in United States; piperacillin/tazobactam (Zosyn, Lederle) is available ⁴³⁷ Ratites (chicks <6 mo of age) Amazon parrots Psittacines/PD Ostriches (chicks)/administer concurrent to amikacin (20 mg/kg IM q12h) Pigeons, raptors, cranes Red-tailed hawks, great horned owls/PD Most species, including psittacines Budgerigars (PD), raptors Most species, including passerines Eggs/inject 200 mg/ml solution into air cell on days 14, 18, and 22
	25 mg/kg IM ⁶¹⁰ 75–100 mg/kg IM q4–6h ^{610,611} 100 mg/kg IM q12h ¹⁴² 100 mg/kg IM q12h ¹ 100 mg/kg IM, IV q8–12h ^{234,446,502,546} 100 mg/kg IM q4–6h ⁵²⁴ 100–200 mg/kg IM, IV q6–12h ^{542,546} 200 mg/kg IM q8h ^{261,515} 200 mg/kg IM, IV q4–8h ^{177,542,610} 0.02 ml (4 mg) in macaw eggs; 0.01 ml (2 mg) in small eggs ⁴⁰¹	
Polymyxin B (Polymyxin B Sulfate, Roerig)	—	Polypeptide antibiotic; effective against most gram-negative bacteria; potentially significant adverse effects on the renal and neurologic systems ⁴
	10–15 mg/kg IM q24h ²⁵³ 50,000 IU/L drinking water ²⁹³ 50,000 IU/kg soft feed ²⁹³	Raptors/not absorbed if given PO Canaries Canaries
Povidone-iodine (Betadine Surgical Scrub, Purdue Frederick)	Topical to lesions, then wash off ⁴⁴	Raptors/wound cleansing; antibacterial, antifungal activity
Rifabutin (Mycobutin, Pharmacia)	15–45 mg/kg PO q24h ^{145,541,620}	Most species including passerines/ <i>Mycobacterium</i> ; use in combination with other agents (see Appendix 42)
Rifampicin (see rifampin)	—	
Rifampin (Rimactane, Ciba; Rifadin, Marion Merrell Dow)	—	Most species/ <i>Mycobacterium</i> ; use with other agents (see Appendix 42); may cause/be associated with hepatitis, CNS signs, depression, and vomiting; yellow-orange urates observed in bustards ⁵⁴⁶ Most species including passerines, psittacines/ <i>Mycobacterium</i> Most species, including Amazon parrots, cranes
	10–20 mg/kg PO 12–24h ^{145,546,610} 45 mg/kg PO q24h ^{568,620}	
Sarafloxacin (SaraFlox, Abbott)	—	Fluoroquinolones; prohibited in food-producing poultry ¹⁸⁸ Broiler chickens/PD Broiler chickens/colibacillosis Turkeys/colibacillosis Chicks (1 day old)/colibacillosis
	10 mg/kg PO q8h ¹³⁶ 20–40 mg/L drinking water × 5 days ¹⁸⁷ 30–50 mg/L drinking water × 5 days ¹⁸⁷ 0.1 mg SC ¹⁸⁷	
Silver sulfadiazine (Silvadene Cream 1%, Marion Merrell Dow)	Topical q12–24h ^{163,519}	Most species/burns, ulcers; Amazon foot necrosis; bandage application preferred

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Spectinomycin (Spectam, Agri Labs)	10–30 mg/kg IM q8–12h ⁴⁵	Psittacines	159
	25–35 mg/kg IM q8–12h ²³⁵	Pigeons	
	165–275 mg/L drinking water ²³⁶	Pigeons	
	200–400 mg/L drinking water ¹⁴³	Canaries	160
	400 mg/kg soft feed ¹⁴³	Canaries	
Spiramycin (Provamycin, Rovamycin)	—	Not available in the United States	
	20 mg/kg IM q24h ²⁵³	Raptors	
	250 mg/kg PO q24h ³⁹⁶	Most species, including raptors/poorly absorbed	
	200–400 mg/L drinking water ¹⁴³	Canaries	
	400 mg/kg soft feed ¹⁴³	Canaries	
Streptomycin (Streptomycin Sulfate, Roerig)	—	May be nephrotoxic; not recommended ⁵¹⁹ ; consider amikacin as an alternative; <i>Mycobacterium</i> ; use in combination with other agents (see Appendix 42)	
	15 mg/kg PO q24h ²⁵³	Raptors/highly neurotoxic	
	25–50 mg/kg IM q24h ¹⁴²	Chickens/PD	
	30 mg/kg IM q12h ³⁸	Most species	
Sulfachlorpyridine (Vetasulid, Solvay Animal Health)	150–300 mg/L drinking water ⁵¹⁹	Canaries	
	400 mg/L drinking water × 7–10 days ⁵³⁷	Pigeons	
Sulfadimethoxine (Albon, Pfizer)	—	See sulfonamides	
	190–250 mg/L drinking water ³⁹⁶	Pigeons/loading dose 375 mg/L drinking water	
	330–400 mg/L drinking water on day 1 followed by 200–265 mg/L × 4 days ²³⁶	Pigeons	
Sulfadimidine (Sulmet, Fort Dodge)	—	See sulfonamides	
	220 mg/L × 3 days, off 2 days, on 3 days ¹⁰⁶	Psittacines, pigeons	
	2000 mg/L drinking water × 3 days ⁴⁹	Pigeons/repeat dose 1–2× at 2-day intervals	
Sulfaquinoxaline (Sulquin 6–501, Solvay Animal Health; Sul-Q-Nox, Alfarma)	—	See sulfonamides	160
	250–500 mg/kg feed ⁸³	Waterfowl/avian cholera, new duck disease	
Sulfonamides	—	Broad-spectrum antimicrobial; prohibited in food-producing birds ⁶⁴⁰ contraindicated with dehydration, liver disease, or bone marrow suppression; gastrointestinal upset, regurgitation are common especially in macaws; resistance by <i>Pseudomonas</i> is common ⁵⁴² use for longer than 2 wk may require vitamin supplementation	161
Tetracycline (Tetracycline Soluble Powder, Butler; Panmycin Aquadrops, Upjohn)	—	Products or foods containing Al, Ca, Mg, or Fe reduce or alter absorption; outdated tetracycline is nephrotoxic ²⁰⁰	
	50 mg/kg PO q8h ^{145,519}	Most species, including passerines	
	200–250 mg/kg PO q12–24h ^{95,518}	Most species/gavage	
	40–200 mg/L drinking water ^{49,83,95}	Most species, including game birds	
	100 mg/L drinking water ⁵⁰¹	Rheas	
	200 mg/L ⁵³⁸	Pigeons	
	666 mg/L drinking water ⁵⁴⁶	Pigeons	
	100–600 mg/kg feed ^{49,83}	Game birds	

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Tiamulin (Denegard, Fermenta; Tiamutin, Novartis)	—	Bacteriostatic antibiotic; effective against <i>Mycoplasma</i> , some gram-positive and gram-negative bacteria, and spirochetes ⁴⁷³	161
	25–50 mg/kg PO q24h ¹⁴² 30 mg/kg PO q24h × 7 days ⁴⁸⁶ 60 mg/kg PO q24h × 7 days ⁴⁸⁶ 225–250 mg/L drinking water × 3–7 days ^{49,546} 1000 mg/L water ⁴⁸⁶ 300–400 mg/kg feed × 7 days ^{49,486}	Most species Poultry adults Poultry chicks Poultry, pigeons Poultry eggs/dip Game birds	
Tiamulin/chlortetracycline (Tetramutin, Novartis)	1.0–1.5 mg/kg feed × 7 days ⁵⁸⁶	Chickens/ <i>Mycoplasma</i> ; may be used with salinomycin at 60 mg/kg without signs of incompatibility	161
Ticarcillin (Ticar, SmithKline Beecham)	—	Extended-spectrum penicillin	162
	75–100 mg/kg IM q4–6h ⁵⁴² 150–200 mg/kg IV q2–4h ¹⁴⁵ 200 mg/kg IM, IV q6–12h ^{67,539} 200 mg/kg IM q2–4h ⁵⁵⁵	Amazon parrots Passerines, soft bills Most species, including pigeons, raptors/ <i>Pseudomonas</i> ¹⁷⁴ Blue-fronted Amazon parrots/PD	
Ticarcillin/clavulanic acid (Timentin, SmithKline Beecham)	100 mg/kg IM, IV ¹⁰⁵ 200 mg/kg IM, IV q12h ⁵³⁸	Most species/frequency not reported Most species	
	—	Macrolide; handle with caution; potentially fatal to humans ⁴⁷³	
Tilmicosin (Micotil 300 Injection, Elanco)	100–500 mg/L drinking water × 5 days ^{299,317}	Poultry chicks/ <i>Mycoplasma</i>	
Tobramycin (Tobramycin, Elkins-Sinn; Nebcin Injection, Lilly; Tobralax, Alcan)	—	Aminoglycoside; used only for severe infections caused by resistant <i>Pseudomonas</i> infections ⁵⁴⁶ ; neurotoxicity (irreversible auditory and vestibular ototoxicity) or nephrotoxicity may develop ⁴	
	2.5 mg/kg IM q8h ¹⁰⁶ 2.5–5.0 mg/kg IM, IV q12h ^{542,546} 5 mg/kg IM q12h ³⁸ 10 mg/kg IM q12h × 5–7 days ^{107,415} 0.25–0.5 ml intra-articular flush q24h × 7–10 days ⁴⁴ Topical ²³²	Psittacines Psittacines, passerines, raptors, pheasants, cranes Most species Raptors Raptors/septic arthritis A mixture of lincomycin (50 mg/ml) and tobramycin (10 mg/ml) was used to flush the flexor tendon sheath	
Trimethoprim (Trimethoprim, Biocraft; Proloprim, Glaxo Wellcome; Trimpex, Roche)	— 10–20 mg/kg PO q8h ^{140,144,396}	Bacteriostatic activity against some gram-positive and gram-negative bacteria Psittacines, passerines, pigeons (PD)	162

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Trimethoprim/sulfadiazine (Tribrissen, Schering-Plough; Septra, Monarch)	—	See sulfonamides	163
	8 mg/kg SC, IM q12h ⁴⁴⁶	Cranes	
	12–60 mg/kg PO q12h × 5–7 days ⁴⁴	Raptors/useful for sensitive infections in neonates	
	16–24 mg/kg PO q8–12h ⁴⁴⁶	Cranes	
	20 mg/kg SC, IM q12h ¹⁰⁶	Psittacines	
	60 mg/kg PO q12h ²³⁶	Pigeons	
	107 mg/L drinking water ⁴⁹	Galliformes	
Trimethoprim/sulfatroxazole	—	See sulfonamides	
	10–50 mg/kg PO q12h ¹⁴⁵	Passerines	
Trimethoprim/sulfamethoxazole (Bactrim, Roche; Septra, Burroughs Wellcome)	—	See sulfonamides	
	8 mg/kg IM q12h ⁵⁴⁶	Psittacines	
	10–50 mg/kg PO q24h ¹⁴⁵	Passerines	
	20 mg/kg PO q8–12h ⁵⁴⁶	Psittacines	
	21 mg/kg PO q12h ¹	Ostriches	
	48 mg/kg PO, IM q12h ³⁰²	Raptors	
	40–50 mg/kg PO q12h ¹⁷⁷	Psittacines	
	60 mg/kg PO q24h ¹⁴⁰	Pigeons/PD	
	60–72 mg/kg PO q12h ⁷⁸	Cranes	
	75 mg/kg IM q12h ³⁸	Most species/reduce dose if regurgitation occurs ¹⁷⁴	
	100 mg/kg PO q12h ³⁸	Most species, including psittacines	
	144 mg/kg PO q8–12h ⁵⁴²	Most species	
	360–400 mg/L drinking water × 10–14 days ⁵³⁷	Most species, including pigeons	
Tylosin (Tylan, Tylan Soluble Powder, Elanco)	—	Macrolide; effective against gram-positive bacteria, <i>Myco-plasma</i> , <i>Chlamydophila</i> , <i>Pasteurella</i> ; very irritating to muscles when administered IM ²³⁵	163
	3–5 mg/kg IM, IV q12h ⁶¹²	Ratites	
	5–10 mg/kg PO q8h ⁶¹²	Ratites	
	6.6–11 mg/kg SC	Galliformes ^b	

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	10–40 mg/kg IM q6–8h ^{145,519} 15 mg/kg IM q8h ³⁶³ 15–30 mg/kg IM q12h × 3 day ^{44,107} 17 mg/kg IM q24h × 7 days ⁴¹⁴ 20–30 mg/kg IM q8h × 3–7 days ⁴⁴ 20–40 mg/kg IM q8h ⁵⁴⁶ 25 mg/kg IM q8h ³⁶³ 25 mg/kg IM q6h ³⁶³ 30 mg/kg IM q12h ⁴⁴ 50 mg/kg PO q24h ^{49,145} 50 mg/L drinking water ⁵³⁸ 250–400 mg/L drinking water ¹⁴³ 300 mg/L drinking water × 6 wk ⁴⁴¹ 500 mg/L drinking water × 3–28 days ^{49,299,546,598} 800 mg/L drinking water ²³⁶ 1000 mg/L drinking water × 21 days ³⁹⁷ 2000 mg/L drinking water ^{234,235} 200 mg/kg feed ⁴⁹ 100 mg/10 ml saline nasal flush ⁴⁴ × 10 days ⁵⁴⁶	Poultry, passerines Cranes/PD Raptors Emus/ <i>Mycoplasma</i> Waterfowl/ <i>Mycoplasma</i> Psittacines Emus/PD Pigeons (PD), quail (PD) Most species/ <i>Mycoplasma</i> Passerines, pigeons Most species Canaries House finches/ <i>Mycoplasma</i> Pigeons, galliformes, waterfowl, emus/ <i>Mycoplasma</i> Pigeons House finches/ <i>Mycoplasma</i> ; give in conjunction with ophthalmic ciprofloxacin Pigeons, poultry/ <i>Mycoplasma</i> , <i>Haemophilus</i> Galliformes Waterfowl/ <i>Mycoplasma</i>	164
Virginiamycin (Stafac, Pfizer)	22 mg/kg feed ⁵⁹⁷	Poultry	
<p>a Most drug doses used in birds should be considered experimental. Patients should be monitored for adverse effects and treatment failure.¹⁷⁷</p> <p>b Ley D. Personal communication. 1997.</p>			

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TABLE 20 Antifungal agents used in birds.^a

Agent	Dosage	Species/Comments
Acetic acid (vinegar)	16 mL/L drinking water ²⁹³	Most species/gastrointestinal yeast infections
Amphotericin B (Fungizone, Squibb; Amphotec, Intermune)	— 1.5 mg/kg IV q8h × 3–7 days ^{37,171,504} 1 mg/kg IT q8–12h ^{504,518,519} 1 mg/kg IT q12h × 12 days, then q48h × 5 wk ⁴⁴ 100–109 mg/kg PO by gavage q12h × 10–30 days ^{396,416,471,473} 0.05 mg/mL sterile water ³⁷ 0.2 mL PO q12h × 10 days ¹⁰⁶ 1000 mg/L drinking water × 10 days ¹⁶⁸ 0.25–1.0 mL PO q24h × 4–5 days ⁴⁴ Topical ¹⁰⁶	Fungicidal; megabacteria/avian gastric yeast; preferred IV agent for aspergillosis; IT administration for syringeal aspergilloma may cause tracheitis; potentially nephrotoxic; resistance may develop ⁴⁷⁰ Most species Psittacines, raptors/aspergillosis Raptors/syringeal aspergilloma Budgerigars/megabacteria/avian gastric yeast; compound in simple syrup; resistance reported in bud-gerigars in Australia ⁴⁷¹ Most species/nasal flush Budgerigars/avian gastric yeast; use IV formulation (5 mg/mL) Budgerigars/avian gastric yeast Raptor neonates/candidiasis; not absorbed from alimentary tract Apply 10% solution to oropharynx
Amphotericin B (A)/proteolytic nasal flush (P)	Nasal flush (A) 1 mg/kg + (P) 0.2–0.4 mL diluted in 20 mL saline ⁸ q24h	Uses a commercial neomycin-chymotrypsin-trypsin-hydrocortisone ointment (Kymar, Schering-Plough); 10 mL per naris (flushed vigorously in small amounts)
Amphotericin B (3% cream)	Topical to affected area q12h ^{293,519}	Most species/mycoses
Caprylic acid (Kaprycidin A, Ecological Formulas)	271 mg/kg PO ⁶¹³	Most species/adjunctive treatment with imidazoles; seldom used
Chlorhexidine (Hibiclens, Astra Zeneca)	—	Antiseptic poorly absorbed from the gastrointestinal tract; may not be palatable to canaries; offering treated drinking water may result in a potentially fatal reduction in water consumption ¹¹
	0.05% (0.5 mL or 500 mg/L drinking water or saline) PO ⁴⁰ 2.6 mL/L drinking water ⁵⁹² 2.6–6.6 mL/L drinking water ⁶¹¹	Most species/ingluvial yeast infections; may be toxic to finches ⁵⁴⁶ Finches/endoventricular mycoses; use with flucytosine or itraconazole Psittacines/prevent or treat mild gastrointestinal candidiasis

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Clotrimazole (Lotrimin, Schering-Plough)	—	Broad-spectrum antifungal agent; inhibits the growth of pathogenic yeasts such as <i>Candida albicans</i> ; used commonly as adjunctive therapy for aspergillosis; administer by air sac, IT, nebulization, or topically	
	2 mg/kg IT q24h × 5 days ⁵³⁸	Psittacines/syringeal aspergilloma; apply with catheter directly into syrinx during anesthesia	
	Inject 10 mg/kg into air sacs ⁵³⁸	Psittacines/dilute in propylene glycol to 2.5 mg/ml; divide total dose between the 4 most accessible air sacs; toxic and may result in death in African grey parrots and other birds if injected into the muscle or viscera ⁵³⁸	
	10 mg/ml saline flush ^{171,471}	Most species/effective against <i>Aspergillus</i> at sites that can be flushed; nasal flush using 1% solution	
Enilconazole emulsion (Imaverol, Janssen; Clinafarm, Sterwin)	—	Imidazole antifungal agent with activity against <i>Penicillium</i> and dermatophytes ¹¹	
	6 mg/kg PO q12h ¹¹	Eclectus parrots/glossal candidiasis; an elevation of AST was seen after 7 days of treatment ¹¹	
	1 mg (0.5 ml)/kg IT of a 1:10 dilution q24h × 7–14 days ⁵⁴⁶	Falcons/aspergillosis	
	200 mg/L drinking water ¹¹	Canaries/cutaneous dermatophytosis	
	Topical 1:10 dilution q12h × 21–28 days ⁴⁴	Raptors/cutaneous aspergillosis, candidiasis	
	Topical or intratracheal 1:10–1:100 dilution ⁴⁵	Psittacines/aspergillosis, candidiasis	
	3 topical soakings q3d ⁵⁰⁴	Raptors, ostriches/dermatophytosis	166
Fluconazole (Diflucan, Roerig)	—	Fungistatic; penetrates well into brain, cerebrospinal fluids, and eyes ¹¹ ; only indicated if topical treatment (e.g., nystatin) is not feasible ¹¹ ; water-soluble; safest therapeutic index of the azoles; <i>Candida</i> , avian gastric yeast; may be ineffective against aspergillosis ⁵⁰⁴ ; death observed in budgerigars at 10 mg/kg PO q12h (this dose was also ineffective against avian gastric yeast) ⁴⁷¹	167
	2–5 mg/kg PO q24h × 7–10 days ^{44,451}	Most species, including raptors/gastrointestinal, systemic candidiasis; CNS, ocular mycoses	
	4–6 mg/kg PO q12h ¹⁷²	Juvenile psittacines/candidiasis	
	5–10 mg/kg PO q24h ³⁶	Gouldian finches/candidiasis; can be administered in orange juice	
	5–15 mg/kg PO q12h × 14–60 days or longer ⁵³⁸	Most species/aspergillosis, mycelial candidiasis; use lower dose for candidiasis	
	8 mg/kg PO q24h × 30 days ⁶¹¹	Psittacines/cryptococcosis	
	10–20 mg/kg PO × 30 days ²⁹³	Red-tailed hawks, gyrfalcons/aspergillosis	
	15 mg/kg PO q12h ≥28 days ⁵⁴⁰	Pigeons/aspergillosis	
	15 mg/kg PO q12h 30 days after cessation of clinical signs ⁸	Psittacines/chronic nasal aspergillosis	
	20 mg/kg PO q48h ¹⁷²	Psittacines/PD; mucosal, systemic yeast infections; 2–3 treatments for resistant candidiasis	
	100 mg/kg PO q24h ⁴⁷⁰	Chickens/avian gastric yeast	
	100 mg/kg soft food ³⁶	Gouldian finches/candidiasis	
	25 mg/L nectar ²⁴⁴	Hummingbirds/aspergillosis	
	50 mg/L drinking water × 14–60 days ⁵³⁸	Most species/systemic mycoses; candidiasis	
	150 mg/L drinking water ³⁶	Gouldian finches/candidiasis	167

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Flucytosine (Ancobon, Roche)	—	<p>Fungistatic agent; used prophylactically in raptors (especially falcons) and waterfowl to prevent aspergillosis^a; may be administered as adjunctive treatment; about 50% of <i>Aspergillus</i> strains are resistant⁵²⁶; toxicity is low, but adverse effects may include gastrointestinal effects, hepatotoxicity, bone marrow depression^{57,526}</p> <p>Raptors/aspergillosis</p> <p>Psittacines/generalized yeast or fungal infections</p> <p>Psittacines, passerines, raptors</p> <p>Raptors/aspergillosis prophylaxis</p> <p>Psittacines, mynah birds</p> <p>Most species, including galliformes, swans/syringeal aspergilloma</p> <p>Raptors/prophylactic for prevention of aspergillosis^a; recommended to treat for 1 wk before and 2 wk after move; used routinely for domestically raised gyrfalcons and gyrfalcon hybrids from age 45 days</p> <p>Most species</p> <p>Ratites</p> <p>Psittacine neonates</p> <p>Raptors/aspergillosis</p> <p>Most species, including psittacines, galliformes, swans/syringeal aspergilloma</p> <p>Raptors/candidiasis</p> <p>Finches/endoventricular mycoses; can use with chlorhexidine in drinking water</p>	168
5-Fluorocytosine	—	See flucytosine	168
Fumagillin (Clemastine Fumarate, Schein)	0.25–1.0 ml PO q24h × 4–5 days ⁵⁴⁶	<p>Amebicide once used to treat malaria; also used for the control of microsporidia and protozoa; candidiasis; not absorbed from the alimentary tract; safe for young neonates</p> <p>Crop or skin-fold candidiasis</p>	169
Gentian Violet (Brite-Life Gentian Violet, Bergen Brunswick)	Topical q24h ⁵⁴⁶	Crop or skin-fold candidiasis	
Griseofulvin (FulvinP/G, Schering-Plough)	<p>10 mg/kg PO q24h × 21 days^{44,546}</p> <p>30–50 mg/kg in drinking water q24h^{396,612}</p>	<p>Pigeons/dermatophytosis; gavage</p> <p>Ostriches/mycotic dermatitis</p>	
Iodine, 1% solution (Povidex, Morton Grove Pharmaceutical)	Topical ⁵⁰⁴	Oral or cutaneous candidiasis	

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Itraconazole (Sporanox, Janssen)	—	<p>Most species/systemic mycoses, superficial candidiasis, dermatophytosis; fungistatic; maximal oral bioavailability when taken with a full meal⁴; as an inhibitor of the cytochrome, coadministration with other drugs primarily metabolized by this enzyme system may lead to increased plasma concentrations that could increase or prolong both therapeutic and adverse effects⁴; in humans, absorption of liquid and capsule forms differ and oral solution is not taken with food; PD studies in birds have used the capsule form¹¹</p> <p>Commercially available suspension is recommended as a first choice; approximately 0.35–0.39 mg/granule (approximately 285–290 granules per capsule,⁵³⁸ but number and drug concentration can vary considerably); method of compounding with strong acid and orange juice has been reported^{453,454}</p> <p>African grey parrots/anorexia, depression, and toxicity reported at higher doses in this species¹⁷⁵</p>	169
	<p>2.5–5.0 mg/kg PO q24h^{453,471}</p>		
	<p>5 mg/kg PO q24h⁸</p> <p>5–10 mg/kg PO q24h⁴⁵³</p> <p>5–10 mg/kg PO q12–24h × 10–14 days, then q48h²⁷⁰</p> <p>5–10 mg/kg PO q12–24h³⁰²</p> <p>5–10 mg/kg PO q12h × 5 days, followed by q24h for a total of 14 days⁵⁰⁴</p> <p>5–10 mg/kg PO q12h × 5 days, followed by q24h × 60–90 days⁵⁰⁴</p> <p>5–10 mg/kg PO q12h^{311,518}</p> <p>6 mg/kg PO q12h³⁷⁴</p> <p>6–8 mg/kg PO q12h × 5–7 days then q24h × 14 days⁵⁰⁴</p> <p>6–10 mg/kg PO²⁹¹</p> <p>10 mg/kg PO q24h^{298,451}</p> <p>10 mg/kg PO q24h × 14–90 days with food^{451,454,471}</p> <p>10 mg/kg PO q12–24h⁴⁵⁴</p> <p>10 mg/kg PO q12h × 21–60 days^{106,592}</p> <p>15 mg/kg PO q12h up to 4–6 wk²⁷⁰</p> <p>26 mg/kg PO q12h³⁷²</p>	<p>Galliformes, swans, ratites/aspergillosis</p> <p>Blue-fronted Amazon parrots/PD; aspergillosis; 10 mg/kg is required to achieve therapeutic concentrations in poorly perfused tissues</p> <p>Raptors/aspergillosis prophylaxis^a</p> <p>Raptors</p> <p>Raptors/class I aspergillosis (mild, vague signs with inconclusive diagnostics or without histologic confirmation)</p> <p>Raptors/class II-IV aspergillosis</p> <p>Passerines (towhees), waterfowl, penguins/aspergillosis prophylaxis in passerines; aspergillosis, candidiasis, cryptococcosis in others</p> <p>Pigeons/PD; dosage will achieve fungicidal plasma concentrations</p> <p>Raptors/prevention of aspergillosis^a; recommended to treat for 1 wk before and 2 wk after move, and routinely for domestically raised gyrfalcons and gyrfalcon hybrids from age 45 days</p> <p>Ratites/preferred azole</p> <p>Red-tailed hawks (PD), gentoo penguins (PD)¹¹/steady-state plasma concentrations achieved within 2 wk</p> <p>Psittacines/use in combination with nonazoles</p> <p>Pigeons</p> <p>Finches/endoventricular mycoses; can use with chlorhexidine in drinking water</p> <p>Raptors/aspergillosis</p> <p>Pigeons/PD; fungicidal levels achieved in respiratory tissue; further toxicologic studies are</p>	<p>170</p> <p>170</p> <p>170</p> <p>171</p>

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	200 mg/kg feed up to 100 days ⁵¹³	required Gouldian finches/PD; dermatomycoses; beads from capsules were mixed with small amount of oil and seed	
Ketoconazole (Nizoral, Janssen)	— 3 mg/kg PO q24h × 7 days ⁴⁹ 5–10 mg/kg PO q24h ⁶¹² 8 mg/kg PO q12h × 30 days ⁴⁹ 10–20 mg/kg PO q24h ⁴⁹ 10–30 mg/kg PO q12h × 30–60 days ⁵³⁸ 12.5 mg/kg PO q24h × 30 days ⁵¹⁹ 15 mg/kg PO q12h ³⁰² 20 mg/kg PO q24h × 14 days ¹⁰⁶ 20 mg/kg PO q12h ³⁰⁶ 20 mg/kg PO q8h × 7–14 days ⁴⁷¹ 20–30 mg/kg PO q8h ¹⁷¹ 20–40 mg/kg PO q12h × 15–60 days ⁵³⁹ 25 mg/kg PO q12h × 14 days ⁵⁴⁶ 30 mg/kg PO q12h × 7–14 days ³²⁵ 30 mg/kg PO q12h × 7–30 days ^{325,538}	Most species/systemic mycoses (e.g., aspergillosis), candidiasis; fungistatic; less toxic than amphotericin B; more toxic than itraconazole; may be associated with potentially fatal hepatotoxicity ⁴ ; >20 mg/kg may cause regurgitation (if regurgitation, discontinue for 1–2 days, then restart) Pigeons Ratites Ostriches Ostriches Most species Swans/candidiasis Raptors/candidiasis Psittacines, passerines, raptors Psittacine neonates Psittacines/refractory candidiasis Cockatoos Pigeons Ratites, raptors/aspergillosis Amazon parrots/PD Pigeons (PD), raptors/prophylactic in raptors for aspergillosis	171
	50 mg/kg/day PO ¹⁰⁸ 60 mg/kg PO q12h ⁶³⁰ 200 mg/L drinking water, nectar, or soft feed × 7–14 days ^{36,143,244}	Toucans Raptors/PD (common buzzard); aspergillosis Canaries, hummingbirds, gouldian finches/dissolve crushed tablet in ½ -1 tsp vinegar	172
Miconazole (Daktarin, Janssen; Daktarin Oral Gel, Janssen-Cilag; Micazole Lotion, Burns Veterinary Supply; Micatin, Advanced Care Products)	— 5 mg/kg IT q12h × 5 days ⁶³⁴ 10 mg/kg IM q24h × 6–12 days ⁵⁴⁶ 20 mg/kg IV q8h ⁵⁴⁶ Topically apply gel liberally q12h × 5 days ⁵⁵⁰ Topical to affected areas q12h ^{504,591}	Fungistatic; inhibits the growth of <i>Candida albicans</i> , <i>Malassezia</i> , and dermatophytes; injectable miconazole is not available in the United States Psittacines/10 mg/ml solution diluted with saline; syringeal mycoses; use with flucytosine; not available in United States; miconazole and clotrimazole may be an alternative Raptors/generalized aspergillosis Psittacines/candidiasis, cryptococcosis Falcons/candidiasis Cutaneous fungal infections; used in conjunction with oral itraconazole, dermatophytosis	

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Nystatin (Mycolog, Bristol-Myers Squibb)	—	Drug of choice for treatment of candidiasis; not systemically absorbed across intact gastrointestinal tract ^{4,11} ; oral lesions must be treated by direct contact with medication ¹¹ ; when treating neonates, administer separately from formula to maximize concentration and contact time ¹¹ Pigeons/candidiasis Pigeons, raptors Ratites Most species, including waterfowl	172
	20,000–100,000 IU PO q24h × 7 days ^{49,546} 100,000 IU/kg PO q12h ^{235,302} 250,000–500,000 IU/kg PO q12h ⁶¹² 300,000 IU/kg PO q12h × 7–14 days ^{44,171}		
	300,000–600,000 IU/kg PO q8–12h × 7–14 days ¹⁰⁶ 250,000–430,000 IU/kg PO q12h ¹⁰⁶ 500,000 IU/kg PO q8h × 5 days ¹¹⁵ Topical q6h ²⁷⁵ 25,000 IU/L nectar ²⁷⁵ 100,000 IU/L drinking water ^{36,143} 5,000,000 IU/L drinking water ¹⁶⁸ 200,000 IU/kg soft feed ^{36,44} 5000 IU/bird PO q12h × 10 days ^{168,169}	Psittacines Hummingbirds Toucanette (safron)/ <i>Candida</i> Hummingbirds/candidiasis; direct application using a cotton swab Hummingbirds Canaries, finches Goldfinches/megabacteria Canaries, finches Goldfinches/avian gastric yeast; ineffective in budgerigars	173
Parconazole (Parcomyc, Janssen-Cilag)	30 mg/kg feed ⁵²⁶ 60 mg/kg feed × 7–10 days ⁵²⁶	Guinea fowl/ <i>Candida</i> ; prophylactic; not available in the United States Guinea fowl/ <i>Candida</i> ; therapeutic	
Povidone iodine (Betadine Surgical Scrub, Purdue Frederick)	Topical to lesions, then rinse ⁴⁴	Raptors/wound cleansing; antibacterial, antifungal activity	
Silver sulfadiazine (Silvadene Cream 1%, Marion Merrell Dow)	Topical to affected areas q12–24h ^{163,519}	Most species/bandage application preferred	
STA solution (salicylic acid 3 g, tannic acid 3 g, ethyl alcohol to 100 ml)	Topical ⁵⁴⁶	Fungal dermatitis	
Terbinafine (Lamisil, Novartis)	10–15 mg/kg PO q12–24h ¹²²	Aspergillosis; fungicidal; excellent therapeutic potential for the treatment of aspergillosis in avian species; higher dose may be more effective	
Terconazole (Terazol, Janssen)	60–100 mg/kg feed ³⁹⁶	Ostriches/candidiasis	173
Voriconazole (Vfend, Pfizer)	10 mg/kg PO q12h ³⁴¹	Cockatiel/aspergillosis; use in one case showed initial response to treatment; used in conjunction with amphotericin; further use in birds needs to be evaluated; expensive	174
a Prophylactic use of antifungal agents may be indicated in newly captured or admitted birds of susceptible species and in birds undergoing change of management or transfer of enclosure. ⁵⁰⁴			

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TABLE 21 Antiviral and immunomodulating agents used in birds.

Agent	Dosage	Species/Comments
Acemannan (Carravet, Carrington Laboratories)	1 mg/kg SC q7d ⁶⁴⁶ 2 mg/kg intralesional q7d × 4 treatments ⁶⁴⁶	Chemotherapeutic adjunct therapy Used before surgical debulking of fibrosarcomas
Acyclovir (Zorivax, Burroughs Wellcome)	— 10 mg/kg IM q24h × 5–14 days starting 3 days postexposure ¹¹² 20–40 mg/kg IM q12h ⁵³⁵ 29 mg/bird PO q8h × 7 days ⁴⁴ 80 mg/kg PO q8h × 7 days ⁴⁴² 330 mg/kg PO q12h × 4–7 days ³⁰⁵ 330 mg/kg PO q12h × 7–14 days ²⁷⁰ ≤400 mg/kg feed ¹¹² 1000 mg/L drinking water ^{112,517}	Antiviral agent; active against herpesviruses and cytomegalovirus; IM injection of the water-soluble sodium salt (IV formulation) may cause severe muscle necrosis; phlebitis and neurologic signs may occur with IV administration; most effective when administered before clinical signs begin; birds should be treated for a minimum of 7 days; the reconstituted solution is unstable and should be divided into aliquots and frozen ^{11,546,611} Chickens/Marek's disease Psittacines/psittacine herpesvirus Pigeons/herpesvirus Quaker parakeets/PD; psittacine herpesvirus prophylaxis or treatment Psittacine neonates/psittacine herpesvirus Raptors/falcon and owl herpesvirus; may cause vomiting Quaker parakeets/herpesvirus Quaker parakeets/herpesvirus; gavage
Amantadine (Symmetrel, Endo Labs)	— 10 mg/kg PO × 3 days pre- and 18 days postexposure ¹¹² 25 mg/kg PO × 10 days after infection ¹¹² 100 mg/L drinking water ¹¹²	Antiviral agent; inhibits replication of influenza A viruses ¹¹² Turkeys/influenza viruses; must be administered before and during virus exposure Chickens Chickens/can use simultaneously with killed influenza vaccine
Echinacea (Echinacea solution, Biobotania)	0.5 ml/kg per L drinking water q24h × 5 days ⁵⁴⁶ 1 ml/L drinking water ⁵¹⁸	Psittacines/holistic immunostimulant Psittacines; use alcohol-free formulation
F10 Super Concentrate (Health and Hygiene Ltd, South Africa)	Nebulize 1:125 for 20 min q8h ⁵⁷⁷	African grey parrots/disinfectant with some antiviral properties; circovirus
Famciclovir (Famvir, Novartis)	25 mg/kg PO q12h ⁶⁰⁷	Ducklings/PD; antiviral agent; duck hepatitis; toxic effects were not reported
Imiquimod cream (Aldara, 3M)	Applied topically 3×/wk several hr before the morning feeding ³⁴⁸	Psittacines/cloacal papillomatosis; thought to boost host cell-mediated immunity; masses decreased in size; complete remission did not occur
ImmunoRegulin (Propionibacterium Acnes, Neogen)	0.13 mg/kg (up to 0.08 mg [0.2 ml] max) SC or IM days 1,3,7,14,28,42, then q30d ³²	Immune therapy for chronic feather pickers; induces macrophage and lymphokine production; enhances cell-mediated immunity; increases natural killer cell activity; do not use with corticosteroids

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Interferon (Roferon-A Injection, Roche; Virbagen Omega, Virbac Animal Health)	—	Interferon α_{2a} : glycoprotein with immunomodulating and antiproliferative capabilities as well as antiviral activity Most species/proventricular dilatation disease; may be associated with temporary clinical improvement Most species/stock solution: mix 1 ml (3,000,000 IU/ml) with 100 ml sterile water (30,000 IU/ml); can freeze as 2 ml vials up to 1 yr; mix 2 ml of stock into 1 L LRS (60 IU/ml); refrigerate up to 3 mo Psittacines African grey parrots/circovirus; omega interferon Pigeons/circovirus	176
30 IU q24h \times 5 days, 30 IU 2 \times /wk \times 2 wk, then 30 IU q7d \times 2 wk ²²⁰			
60–240 IU/kg SC, IM q12h ⁵⁶²			
300–1200 IU/kg PO q12h ⁵³⁸			
1500 IU/kg PO q24h ¹¹			
1,000,000 units IM q48h to q7d \times 3 treatments ⁵⁷⁷			
1000 IU/L drinking water \times 14–28 days ⁵³⁷			
Levamisole (Levasole, Mallinckrodt)	—	Anthelmintic with immunostimulation properties; low therapeutic index (toxic reactions and deaths reported) Poultry Most species, including macaws Most species	177
1.25–2.5 mg/kg PO, SC ⁵¹⁷			
2 mg/kg SC, IM q14d \times 3 treatments ^{63,519}			
11 mg/L drinking water \times 3–5 wk ⁹⁴			
Penciclovir (Denavir, Novartis)	10 mg/kg IP q24h \times 12–24 wk ³⁵⁹	Ducks/PD; antiviral agent active against herpesviruses; duck hepatitis B virus; viral levels were significantly reduced; no toxic effects observed; dissolve in 2 ml of 1% DMSO	
Rimantadine (Flumadine, Forest)	100 mg/L drinking water ¹¹²	Chickens/influenza viruses; must be used before and during exposure	
Silymarin (milk thistle)	100–150 mg/kg PO divided q8–12h ⁸	Hepatic antioxidant; used in patients with liver disease and as ancillary to chemotherapy; use a low-alcohol or alcohol-free liquid formulation	
Vitamin C (ascorbic acid)	20–50 mg/kg IM q1–7d ^{302,519}	Most species, including raptors/antioxidant; immunostimulant; nutritional support	177

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TABLE 22 Antiparasitic agents used in birds.

Agent	Dosage	Species/Comments
Albendazole (11.36%) (Valbazen, SmithKline)	— 5.2 mg/kg PO q12h × 3 days, repeat in 14 days ⁶¹² 10 mg/kg PO once ¹¹⁴ 15–20 mg/kg PO once ¹⁰⁸ 25–50 mg/kg PO q24h × 3–4 days ⁵⁷⁵ 50 mg/kg PO q24h × 5 days ⁷⁶	Broad-spectrum anthelmintic; may be toxic in keas, some Columbiformes at 50–100 mg/kg ^{269,575} Ratites/flagellates, cestodes Poultry/PD Ramphastids Doves, rock partridges/ <i>Capillaria</i> Amazon parrots/microsporidian keratoconjunctivitis
Aminothiazole (Tricoxine, Fabry)	5 mL/L drinking water × 7 days ⁵⁴⁶	Pigeons/ <i>Trichomonas</i> ; avoid overdosing; not available in the United States
Amitraz (Mitaban, Upjohn)	Spray with 0.025% solution (dilute 1 part amitraz [12.5%] with 500 parts water), and repeat in 10 days ⁷²	Ostriches/lice; spray 2.5 L/bird
Amprolium (Corid, Merck)	— 13–26 mg/kg PO ²²⁶ 25 mg/kg/day PO ²³⁷ 30 mg/kg PO q24h × 5 days ²⁵³ 50–100 mg/L drinking water × 5–7 days ^{392,415,546} 60 mg/L drinking water ⁷⁸ 200 mg/L drinking water ²³³ 250 mg/L drinking water × 7 days ⁶³⁵ 575 mg/L drinking water ⁸³ ¼ tsp/L drinking water × 3–5 days ^{233,234} 115–235 mg/kg feed ^{79,573}	Coccidiostat; efficacy is reduced by high doses of thiamine ⁵⁷³ Chickens/PD; bioavailability almost 4 times greater in fasted birds Pigeons Raptors Most species, including parakeets, finches Cranes Pigeons/flock treatment Psittacines (keas)/ <i>Sarcocystis</i> ; use in combination with pyramethamine and primaquine Poultry/use a 9.6% solution Pigeons, poultry/20% soluble powder
Cambendazole (Equiben, Merck)	60–100 mg/kg PO q24h × 3–7 days ³⁹² 75 mg/kg PO q24h × 2 days ²³⁷	Most species Pigeons
Carbaryl 5% (Sevin Dust, Gulfstream)	Topical; light dusting of plumage or nest box litter ^{519,546} 1–2 tsp to nesting material ⁵⁴⁶	Most species/ants, ectoparasites; remove treated litter after 24 hr Ectoparasite control

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Carnidazole (Spartrix, Wildlife Pharmaceuticals)	5 mg/bird PO ⁵³⁹	Doves (adults), pigeons (squabs)	
	10 mg/bird PO ⁷²	Pigeons (adults)	
	20 mg/kg PO once ²³³	Pigeons	
	20 mg/kg q24h PO × 2 days ^{253,302}	Raptors	
	20–30 mg/kg PO once ^{268,392}	Most species, including pigeons/ <i>Trichomonas</i>	
	30 mg/kg PO q12h × 3 days ²⁹⁶	Raptors Cockatiels/ <i>Giardia</i>	
	PO, repeat in 10–14 days ^{293,519}		
	33 mg/kg PO, repeat in 14 and 28 days ³⁶	Society finches, Gouldian finches/flagellates; 0.5 mg/adult (based on 15 g); 0.25 mg/nestling (based on 7.5 g)	
	50 mg/kg PO once ²⁷⁰	Raptors	
	120 mg/kg PO as single dose or divided over 2–5 days ⁶¹⁶	American kestrels, screech owls/ <i>Trichomonas</i> infections resistant to treatment with lower doses	
Chloroquine phosphate (Aralen, Sanofi)	—	<i>Plasmodium</i> ; may be used with primaquine for <i>Haemoproteus</i> and <i>Leucocytozoon</i>	179
	5 mg/kg PO q24h or in feed ^{215,519,573}	Game birds, penguins/in penguins, precede treatment with primaquine by 6 hr	
	10 mg/kg PO q7d ⁵¹¹	Preventive treatment for <i>Plasmodium</i> once bird is stable; use with primaquine (1 mg/kg q7d)	180
	10 mg/kg PO, then 5 mg/kg at 6, 18, and 24 hr ⁵¹⁸	Penguins	
	10 mg/kg PO, then 5 mg/kg at 6, 24, and 48 hr ⁷⁹	Raptors/use with 0.3 mg/kg primaquine (at 24 hr following the initial chloroquine dose) q24h × 7 days	
	20 mg/kg PO or IV, then 10 mg/kg at 6, 18, and 24 hr; repeat q7d × 3–5 treatments ⁵¹⁸	Raptors/ <i>Plasmodium</i> ; IV is recommended for initial dose in acute cases; use with 1 mg/kg primaquine q24h × 2 days	
	25 mg/kg PO, then 15 mg/kg PO at 12, 24, and 48 hr ^{518,567}	Most species, including raptors/use with 0.75–1.0 mg/kg primaquine at 0 hr	
	60 mg/kg PO q24h × 7 days ⁴³⁰	Raptors/ <i>Haemoproteus</i> ; use in conjunction with mefloquine and primaquine	
	2000 mg/L drinking water, grape juice, or orange juice ⁵⁷³	Game birds/juice covers bitter taste of drug	
Chlorsulon (Curatrem, Merial)	20 mg/kg PO q14d × 3 treatments ^{101,518}	Psittacines/trematodes	
	20 mg/kg PO 3×/wk × 14 days ^{44,65}	Waterfowl, raptors/trematodes, cestodes	
Clazuril (Appertex, Janssen)	—	Coccidiostat	
	1.1 mg/kg feed × 5 days ⁵¹⁹	Cranes	
	2.5 mg/bird PO once ⁶²⁵	Pigeons/suppresses oocyst excretion up to 2.5 wk	
	5–10 mg/kg PO q24h × 2 days ²⁵³	Raptors	
	5–10 mg/kg PO q24h × 3 days, off 2 days, on 3 days ³⁹²	Poultry, pigeons	
	5–10 mg/kg PO q72h × 3 treatments ^{44,65}	Waterfowl, raptors	
	6.25 mg/kg PO once ⁵⁴⁶	Pigeons	
	7 mg/kg PO × 3 days, off 2 days, on 3 days ⁴⁵	Psittacines	
Clopidol (25%) (Coyden-25, A.L. Laboratories)	125–250 mg/kg feed ⁵⁷³	Game birds/coccidiosis, <i>Leucocytozoon</i> , <i>Plasmodium</i>	
Crotamiton (Eurax, Westwood-Squibb)	Topical to affected areas ⁹⁴	Mites (e.g., <i>Knemidoptes</i>); use in combination with ivermectin	180
Cypermethrin (5%) (Max Con, Y-Tex)	Spray or dip with 1:100 dilution ⁴⁴	Pigeons, ostriches/lice, mites	181

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Decoquinate (Deccox, Merial)	30 mg/kg feed ⁵⁹⁷	Chickens/coccidia
Deltamethrin (Spot On, Schering-Plough)	50 mg/L topical spray ³⁹⁶	Ostriches/lice; spray until runoff
Dichlorophen (Tapeworm tablets, Happy Jack)	100 mg PO q10 days × 2 treatments, ³¹⁸ repeat in 10 days prn	Pigeons/cestodes; administer after a 12-hr fast
Diclazuril (Clinacox, Schering-Plough)	10 mg/kg PO q24h on days 0, 1, 2, 4, 6, 8, 10 ³⁹⁹ 0.5–1.0 mg/kg feed ³⁹⁶	Hawaiian crows/toxoplasma Chickens, turkeys/coccidia
Dimetridazole	— 100 mg/L drinking water ¹⁴³ 187.5 mg/kg feed ⁵⁷³ 200–400 mg/L drinking water × 5 days ^{9,49} 250 mg/L drinking water × 4–6 days ³⁶ 265 mg/L drinking water ⁷² 300 mg/L drinking water × 10 days ⁵⁴⁶ 400 mg/L drinking water × 3 days ²⁷⁴ 650 mg/L drinking water × 7–12 days ⁵⁴⁶ 800 mg/L drinking water ⁵⁷³ 900 mg/L drinking water × 10 days, followed by 7 g/10 L × 10 days ⁵⁴⁶	<i>Trichomonas</i> , <i>Giardia</i> , <i>Hexamita</i> , <i>Spironucleus</i> , <i>Histomonas</i> ; low therapeutic index; hepatotoxic to lories, some passerines (e.g., robins); not recommended for finches; highly toxic to geese, ducks, and pigeons ⁵⁷³ ; not available in many countries (United States, European Union) because of human health risks; Canada has also proposed its ban in food-producing animals ⁴³⁵ Canaries, finches Poultry, game birds Psittacines, game birds Gouldian finches/ <i>Cochlostoma</i> , <i>Trichomonas</i> Pigeons Bustards/prevention of <i>Trichomonas</i> Pigeons/PD; bioavailability reduced with feed Pigeons Poultry, game birds Bustards/drug of choice for <i>Trichomonas</i>
	¼ –½ tsp/gal drinking water × 3–5 days ²³⁶ ½ tsp/gal drinking water × 5 days ⁵¹⁸ 1 tsp/gal drinking water × 5 days ^{392,402} 185 mg/kg feed ⁷² 200–500 mg/kg feed ⁷²	Pigeons/CNS symptoms if overdosed; because of variable water consumption, use lower dose in hot weather and higher dose in cool weather Lories, mynahs Most species Poultry Ostriches (≤3 mo of age)/ <i>Trichomonas</i>
Dinitolmide (Zoamix, Alpharma)	40–187 mg/kg feed ³⁹⁶	Chickens, turkeys/coccidia
Febantel (Vercom, Rintal, Bayer)	5 mg/kg PO ³⁹⁶ 20 mg/kg PO ³⁹⁶ 30 mg/kg PO once ²⁹ 37.5 mg/kg PO once ⁵⁴⁶	Ostriches Ostriches Pigeons/PD; ascarids; repeated doses required to eliminate <i>Capillaria obsignata</i> Pigeons

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Fenbendazole (Panacur, Hoechst)	—	<p>Most species/anthelmintic effective against cestodes, nematodes, trematodes, <i>Giardia</i>, acanthocephalans; toxicity documented in pigeons and doves^{269,461}; may be toxic for other species, including raptors,⁵³⁸ vultures,^{52,270} lorries,⁴⁶¹ storks^{52,631}; can cause feather abnormalities if administered during molting⁵⁴⁶</p> <p>Chickens/PD; <i>Capillaria</i></p> <p>Waterfowl</p> <p>Pigeons/nematodes</p> <p>Pheasants/<i>Heterakis</i>, ascarids</p> <p>Raptors/nematodes, trematodes</p> <p>Partridges, pheasants/<i>Syngamus</i>, <i>Heterakis</i>, <i>Ascaridia</i></p> <p>Ostriches/wire worms, cestodes</p>	182
	<p>1.5–3.9 mg/kg PO q24h × 3 days⁵⁹⁹</p> <p>5–15 mg/kg PO q24h × 5 days⁵¹⁸</p> <p>10–12 mg/kg PO q24h × 3 days²³⁶</p> <p>10–40 mg/kg PO⁸³</p> <p>10–50 mg/kg PO, repeat in 14 days^{270,302}</p> <p>12 mg/kg PO⁷²</p> <p>15 mg/kg PO²⁹³</p> <p>15 mg/kg PO q24h × 5 days⁵⁴⁶</p> <p>15–25 mg/kg PO × 4–5 days⁵⁶³</p> <p>15–45 mg/kg PO⁷²</p> <p>20 mg/kg PO once⁶⁵</p> <p>20 mg/kg PO q24h × 5 days⁴⁴</p> <p>20 mg/kg PO q24h × 14 days⁴⁴</p> <p>20–50 mg/kg PO q24h⁶¹¹</p> <p>20–50 mg/kg q24h × 3 days, repeat in 21 days²⁷⁰</p> <p>20–100 mg/kg PO once³⁹²</p> <p>25 mg/kg PO, repeat in 14 days^{101,566}</p> <p>25–50 mg/kg PO q24h × 5 days, repeat in 10–14 days²⁷⁰</p> <p>30 mg/kg PO once⁵⁴⁶</p> <p>33 mg/kg q24h × 3 days¹⁰⁶</p> <p>50 mg/kg PO q24h × 3 days^{101,443,539}</p> <p>50 mg/kg PO q24h × 5 days¹⁰¹</p> <p>50 mg/kg PO q12h × 5 days⁵³⁸</p> <p>100 mg/kg PO once, repeat in 10–14 days²⁷⁰</p> <p>100 mg/kg PO q24h × 5 days⁷⁸</p> <p>53 mg/kg feed × 5–7 days⁵⁷³</p> <p>80 mg/kg feed⁵⁹⁹</p> <p>50 mg/L drinking water × 5 days³⁹²</p> <p>125 mg/L drinking water × 5 days³⁹²</p>	<p>Psittacines</p> <p>Tinamous</p> <p>Ostriches</p> <p>Waterfowl/cestodes, nematodes, acanthocephalans</p> <p>Raptors/<i>Capillaria</i></p> <p>Raptors/filarids</p> <p>Psittacines/ascarids, treat once and repeat in 10 days^{546,611}; trematodes and microfilaria, for 3 days; <i>Capillaria</i>, treat for 5 days⁶¹¹</p> <p>Raptors</p> <p>Most species</p> <p>Most species, including owls/ascarids</p> <p>Raptors/<i>Capillaria</i>, spirurids</p> <p>Bustards</p> <p>Psittacines, passerines, raptors/microfilaria, trematodes</p> <p>Most species, including pigeons, Bali mynahs/nematodes, trematodes, <i>Giardia</i></p> <p>Most species/<i>Capillaria</i></p> <p>Cockatoos/filarid adulticide treatment; use with ivermectin (0.2 mg/kg once)</p> <p>Raptors/<i>Capillaria</i>, spirurids</p> <p>Cranes/<i>Capillaria</i></p> <p>Game birds/nematodes, trematodes</p> <p>Chickens/PD; <i>Capillaria</i></p>	183
Fipronil (Frontline, Rhone Merieux)	Spray on skin once, repeat in 30 days prn ⁴⁴	<p>Raptors/ectoparasites; avoid plumage during application; alcohol may create dry, brittle feathers¹⁰⁵</p>	183 184

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Flubendazole (Flutelmium 7.5%, Janssen-Cilag)	5 mg/kg PO once ¹⁴⁷	Poultry/ <i>Syngamus trachea</i>
	10 mg/bird PO ¹⁴⁷	Amazon parrots/ <i>Capillaria</i> and <i>Ascaridia</i> eggs
	30 mg/kg feed × 7 days ¹⁴⁷	Poultry/ <i>Syngamus</i>
	30–60 mg/kg feed × 7 days ⁵⁶³	Tinamous
	60 mg/kg feed × 7–14 days ^{72,105}	Partridges, pheasants
Halofuginone (Stenorol, Collgard, Biopharmaceuticals)	—	Not available in the United States
	1.30–2.72 mg/kg feed ⁸³	Turkeys/coccidia; not approved for birds intended for food
	2.7 mg/kg feed ⁸³	Chickens/coccidia, <i>Plasmodium</i>
Hydroxychloroquine sulfate (Plaquenil, Sanofi Winthrop)	830 mg/L drinking water × 6 wk ²⁹³	Pigeons/ <i>Plasmodium</i>
Hygromycin B (Hygromix 8, Elanco)	9–13 mg/kg feed ⁵⁷³	Game birds/ascarids, cecal worms; some efficacy against <i>Capillaria</i>
	18–26 mg/kg feed × 2 mo ⁵⁷³	Game birds/cecal worms
Iprnidazole (Ipropran, Roche)	—	<i>Giardia</i> , <i>Trichomonas</i> , <i>Histomonas</i> ; not available in the United States; 61 g/2.65 oz
	130 mg/L drinking water × 7 days ^{9,25,392}	Most species, including pigeons
	250 mg/L drinking water × 3–7 days ^{402,539}	Psittacines, pigeons
Ivermectin (Ivomec, Merial)	—	All species/most nematodes, acanthocephalans, leeches, most ectoparasites (including <i>Knemidokoptes</i> , <i>Dermanyssus</i>); can dilute with water or saline for immediate use; dilute with propylene glycol for extended use; parenteral ivermectin may be toxic to finches and budgerigars ¹⁰⁶ ; suspected toxicity reported in a Nanday conure at 0.2 mg/kg ⁴⁶⁷
	0.2 mg/kg PO, SC, IM once ^{49,65,78,265,291,449,573}	Most species, including psittacines, pigeons, raptors, Guinea fowl, waterfowl, ratites, cranes; use in combination with fenbendazole at 50 mg/kg PO q12h × 5 days for microfilaria in cockatoos
	0.2 mg/kg SC, topical on skin ¹⁴⁸	Canaries/quill mites; repeat in 4 days if live mites still present
	0.4 mg/kg SC once ³¹¹	Passerines (towhees)/ <i>Capillaria</i>
	0.4 mg/kg SC once ³⁹²	Raptors
	0.5–1.0 mg/kg PO, IM once ²³⁶	Pigeons
	1 mg/kg SC, repeat in 7–14 days ⁵⁴⁹	Falcons/ <i>Serratospiculum</i>
	1 drop (0.05 ml) to skin q7–14 d ⁵⁴⁶	Pigeons, passerines/ <i>Knemidokoptes</i> , <i>Dermanyssus</i>
	0.8–1.0 mg/L drinking water ¹⁴³	Canaries
Lasalocid (Avatec, Hoffmannla Roche)	67–125 mg/kg feed continuously ^{72,573,597}	Game birds, chickens/coccidia

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Levamisole (Tramisol, Mallinckrodt)	—	Many species/nematodes; immunostimulant; low therapeutic index (toxic reactions and deaths reported); not in use in debilitated birds ³⁹² ; IM administration may cause severe toxicity; limb paralysis, vomiting, dyspnea reported in a parakeet ⁶³⁴ ; do not use in white-faced ibis ⁵¹⁹ or in lorries; withhold food before treatment to prevent regurgitation ³⁹² Ostriches Raptors Most species Psittacines, pigeons, raptors Game birds Waterfowl Ratites	185
	7.5 mg/kg PO, SC ⁷² 10–20 mg/kg PO q24h × 2 days ²⁷⁰ 10–20 mg/kg SC once ³⁹² 20 mg/kg PO once ³⁹² 20–25 mg/kg SC ⁵⁷³ 20–50 mg/kg PO once ^{519,546} 30 mg/kg PO q10d ^{519,612}	40 mg/kg PO once ^{233,392} 80 mg/L drinking water × 3 days ⁵¹⁹ 100–200 mg/L drinking water × 3 days ¹⁰⁶ 264–396 mg/L drinking water × 1–3 days ^{233,392} 265–525 mg/L drinking water × 1 day, repeat in 7–14 days ^{573,640} 375 mg/L drinking water as sole water source for 24 hr, repeat in 7 days ⁵⁴⁶	186
Maduramicin ammonium (Cygro, Roche)	5–6 mg/kg feed ^{396,597}	Psittacines, pigeons, raptors/ <i>Capillaria</i> Finches Psittacines, passerines, raptors Most species, including pigeons Game birds, poultry Pigeons	
Malathion (Prozap Malathion 57EC, Loveland)	Dilute to 0.93% (9300 mg/L); paint or spray perches and premises ⁵⁴⁶	Chickens, turkeys/coccidia; not available in the United States Raptors/organophosphate; premise treatment; <i>Dermanyssus</i>	
Mebendazole (Telmin Suspension, Telmintic Powder, Pitman-Moore)	5–6 mg/kg PO q24h × 3–5 days, repeat in 21 days ²⁹³ 5–7 mg/kg PO ⁶¹² 5–15 mg/kg PO q24h × 2 days ^{415,519} 10 mg/kg PO q12h × 5 days ³⁹² 20 mg/kg PO q24h × 14 days ⁴⁴ 25 mg/kg PO q12h × 5 days ^{115,519} 25 mg/kg PO q12h × 5 days, repeat q30d ²⁷⁰ 50 mg/kg PO, repeat in 10–14 days ²⁷⁰ 10–21 mg/L drinking water × 3–5 days ²⁹³ 1.2 mg/kg feed × 14 days ^{44,65}	Pigeons Ostriches Waterfowl/nematodes ⁴⁴ Canaries/avoid use during breeding season Raptors/filarids Psittacines, ramphastids/nematodes; may not be effective for proventricular and ventricular parasites Raptors/intestinal nematodiasis Raptors/intestinal nematodiasis Pigeons Waterfowl/nematodes	186
Mefloquine HCl (Lariam, Roche)	30 mg/kg PO q12h × 1 day, then q24h × 2 days, then q7d × 6 mo ³⁰³ 50 mg/kg q24h ⁴³⁰	Raptors/ <i>Plasmodium</i> schizonticide Raptors/ <i>Haemoproteus</i> ; used in conjunction with chloroquine at doses up to 60 mg/kg	187

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Metronidazole (Flagyl, Searle)	—	Most species/antiprotozoal, including alimentary tract protozoa (especially flagellates such as <i>Giardia</i> , <i>Histomonas</i> , <i>Spironucleus</i> , <i>Trichomonas</i>) Pigeons, psittacines Psittacines Ratites Psittacine neonates Turkeys/ <i>Trichomonas</i> Companion birds/treatment, control, or prevention of <i>Giardia</i> , <i>Trichomonas</i> , and <i>Hexamita</i> Finches/ <i>Cochlosoma</i> Poultry/PD Raptors Gouldian finches/ <i>Trichomonas</i> Psittacines Rheas Budgerigars Waterfowl/flagellates Raptors/ <i>Trichomonas</i> Pigeons Raptors/ <i>Trichomonas</i>	187
	10–20 mg/kg IM q12–24h × 2 days ^{268,392} 10–30 mg/kg PO, IM q12h × 10 days ^{546,611} 20–25 mg/kg PO q12h ⁶¹² 25 mg/kg PO q12h × 2–10 days ³⁰⁶ 25 mg/kg PO q12h × 10 days ⁸³ 25–50 mg/kg PO q12–24h × 5–10 days ²⁶⁸ 30 mg/kg by gavage once ¹⁶⁷ 30 mg/kg PO q12h ¹¹⁹ 30 mg/kg PO q12h × 5–7 days ⁵⁰⁷ 30 mg/kg PO q12h × 6 days ³⁶ 30 mg/kg PO q12h × 10 days ⁴²⁸ 40 mg/kg PO q24h ⁵⁰¹ 40 mg/kg PO q24h × 7 days ⁴⁹⁸ 50 mg/kg PO ⁸³ 50 mg/kg PO q24h × 5 days ²⁷⁰ 50 mg/kg PO q12h × 5 days ⁵³⁹ 100 mg/kg PO q24h × 3 days ⁵⁴⁹	Poultry/ <i>Histomonas</i> Finches/ <i>Cochlosoma</i> Canaries Passerines/protozoal sinusitis Pigeons Ratites Game birds, passerines/protozoal sinusitis Pigeons Canaries	188
Milbemycin oxime (Interceptor, Ciba-Geigy)	0.2 mg/kg PO q28d ⁸³ 2 mg/kg PO, repeat in 28 days ²⁵²	Turkeys/nematodes Galliformes/nematodes	
Monensin (Coban 45, Elanco)	53–94 mg/kg feed × 10 wk ⁵⁷³ 73 mg/kg feed × 10 wk ⁸³ 94 mg/kg feed ^{80,573} 94–108 mg/kg feed × 8 wk ⁵⁷³	Turkeys Quail Quail, cranes/coccidia; (including disseminated visceral coccidiosis) Chickens	
Moxidectin (ProHeart, Fort Dodge)	0.2 mg/kg IM once ¹¹⁵ 0.2 mg/kg PO ⁵⁴⁹	Ramphastids/repeat if necessary; currently off market Raptors, red-crested cardinals/nematodes; currently off market	
Narasin (Monteban 45, Elanco)	20–80 mg/kg feed ⁵⁹⁷	Chickens/prophylactic coccidiostat; toxic to turkeys	
Nicarbazin (Nicarb 25%, Merck AgVet)	20–125 mg/kg feed ⁵⁹⁷	Chickens/prophylactic coccidiostat	

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Niclosamide (Yomesan, Bayer)	—	Cestodes, trematodes; rarely used since praziquantel is more efficacious; not available in the United States	188
	50–100 mg/kg PO, repeat in 10–14 days ³¹⁵ 220 mg/kg PO, repeat in 10–14 days ²⁴¹ 250 mg/kg PO q14 days prn ⁷⁷	Ostriches Most species Cranes	
	500 mg/kg PO q7d × 4 wk ²⁴¹	Finches	189
Oxfendazole (Benzelmin, Syntex)	5 mg/kg PO once ¹⁰⁵	Ostriches/nematodes	
	10–40 mg/kg PO once ^{392,582}	Most species, including finches/nematodes	
	15–25 mg/kg PO once ¹¹⁵	Ramphastids/repeat in 15 days prn	
	20 mg/kg PO once ²⁵³	Raptors	
Paromomycin (Humatin, Parke-Davis)	—	Highest efficacy of all drugs tested thus far against <i>Cryptosporidium</i> ; oocyst output decreased by 67%–82% in chickens ⁵⁷¹ ; may result in secondary bacterial or mycotic infections; use with caution if ulcerative bowel lesions are suspected because renal toxicity may occur ²⁶⁸	
	100 mg/kg PO q12h × 7 days ⁹⁶	Most species, including macaw chicks/mix a 250 mg capsule with 10 ml water to facilitate dosing; poorly absorbed	
	1000 mg/kg soft food or hulled millet ³⁶	Gouldian finches/cryptosporidiosis; may predispose to fungal infections	
Permethrin (Adams, Pfizer)	Dust plumage lightly ⁴⁴	Pigeons/lice	
Phenylarsonic acid (Nitarson, Merck European Laboratories)	22–45 mg/kg ⁸³	Chickens, turkeys/ <i>Histomonas</i> prevention; not recommended or approved for game birds; not available in the United States	
Piperazine (Wazine, Fleming Laboratories)	—	Most species/ascarids, oxyurids; less efficacious than fenbendazole; seldom used in companion birds	189
	35 mg/kg PO q24h × 2 days ²³⁶	Pigeons/ascarids	
	45–200 mg/kg PO once ⁵¹⁸	Waterfowl/ <i>Tetrameres</i> , <i>Capillaria</i>	
	50–100 mg/kg PO once ^{415,573}	Emus, ostriches, chickens	
	100 mg/kg PO, repeat in 14 days ^{302,392}	Raptors	
	100–400 mg/bird PO ⁵⁷³	Turkeys	
	100–500 mg/kg PO once, repeat in 10–14 days ⁵⁷³	Game birds	
	250 mg/kg PO once ³⁹²	Psittacines, pigeons	
	79 mg/L drinking water × 2 days ²³⁶	Pigeons/ascarids	190
	1000 mg/L drinking water × 3 days ^{44,392}	Raptors, pigeons	
	1000–2000 mg/L drinking water × 1–2 days ^{72,573}	Game birds, pigeons	
	1600–2600 mg/L drinking water ⁸³	Waterfowl/ <i>Tetrameres</i> , <i>Capillaria</i>	
	2000–4000 mg/kg feed ⁵⁷³	Game birds	

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Praziquantel (Droncit, Bayer)	—	Most species/cestodes, trematodes; toxic in finches ⁵¹⁹	190
5–10 mg/kg PO, repeat after 2–4 wk ¹⁰⁶		Psittacines, passerines, raptors	
5–10 mg/kg PO, SC q24h × 14 days ^{44,83,270}		Raptors, waterfowl/trematodes	
6 mg/kg PO, IM, repeat in 10–14 days ⁷⁸		Cranes	
7.5 mg/kg PO ^{49,415}		Ostriches	
7.5 mg/kg SC, IM, repeat in 2–4 wk ¹⁰⁶		Most species except finches	
8.5 mg/kg IM ¹¹		Chickens	
9 mg/kg IM, repeat in 10 days ⁴⁵		Psittacines/cestodes	
9 mg/kg IM q24h × 3 days, then PO × 11 days ^{270,611}		Psittacines, raptors/trematodes	
10 mg/kg PO ¹¹		Chickens	
10 mg/kg IM q24h × 3 days, then PO q24h × 11 days ²¹⁰		Toucans/trematodes	
10 mg/kg PO, SC, IM q24h × 14 days ⁶⁵		Waterfowl, toucans/trematodes; in toucans, follow with 6 mg/kg PO q24h × 14 days ⁵¹⁹	
10–20 mg/kg PO, repeat in 10–14 days ^{49,376}		Most species including pigeons	
10–20 mg/kg SC, IM, repeat in 10 days ⁶⁵		Waterfowl/cestodes	
11 mg/kg SC once ¹¹		Chickens	
25 mg/kg PO, IM, repeat in 10–14 days ⁴⁴³		Bali mynahs/cestodes	191
30–50 mg/kg PO, SC, IM, repeat in 14 days ^{270,302}		Raptors/cestodes	
12 mg (1/2 cat tablet) crushed and baked into 9" × 9" × 2" cake ³⁹²		Finches/withhold regular feed	
Primaquine (Primaquine Phosphate, Sanofi)	—	Pigeons, raptors, game birds, penguins/hematozoa (e.g., <i>Plasmodium</i> , <i>Haemoproteus</i> , <i>Leucocytozoon</i>); use in conjunction with chloroquine; dosage based on amount of active base rather than total tablet weight	
0.03 mg/kg PO q24h × 3 days ^{95,518,573}		Game birds, penguins	
0.3 mg/kg PO (at 24 hr after the initial chloroquine dose) q24h × 7 days ⁷⁹		Raptors/use with chloroquine (10 mg/kg at 0 hr, then 5 mg/kg at 6, 24, and 48 hr)	
0.3 mg/kg PO q24h × 10 days ¹⁹⁶		Penguins/ <i>Plasmodium</i> ; use with chloroquine (10 mg/kg at 0 hr, then 5 mg/kg at 6, 10, and 24 hr)	
0.75–1.0 mg/kg PO once ^{511,567}		Most species, including raptors/use with chloroquine (25 mg/kg at 0 hr, then 15 mg/kg at 12, 24, and 48 hr); palliative therapy	
1 mg/kg PO q7d ⁵¹¹		Use with chloroquine (10 mg/kg q7d) as a preventive regimen for birds recovering from <i>Plasmodium</i> infection	
1 mg/kg PO q24h × 2 days, repeat q7d × 3–5 treatments to prevent relapse ⁵¹¹		Raptors/ <i>Plasmodium</i> ; use with chloroquine (20 mg/kg IV initially, followed by 10 mg/kg PO at 6, 18, and 24h)	
1 mg/kg PO q24h × 45 days ⁶³⁵		Psittacines (keas)/ <i>Sarcocystis</i> ; use in combination with amprolium and pyrimethamine	
1.25 mg/kg PO q24h ¹⁹⁶		Penguins/prophylactic therapy against <i>Plasmodium</i>	

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Pyrantel pamoate (Nemex, Strongid, Pfizer)	—	Intestinal nematodes	191
	4.5 mg/kg PO, repeat in 14 days ⁶⁴³ 5–7 mg/kg PO ⁶¹²	Psittacines (cockatoo chicks) Ostriches	
	7 mg/kg PO, repeat in 14 days ¹⁰¹	Most species	192
	7–20 mg/kg PO, repeat in 14 days ²⁷⁰	Raptors	
	20 mg/kg PO once ⁴⁴	Raptors	
	20–25 mg/kg PO ²³⁴	Pigeons	
	70 mg/kg PO once ¹¹⁵	Ramphastids/repeat if necessary	
	148 mg/L drinking water ⁵³⁸	Psittacines, pigeons/medication floats	
Pyrethrins (0.15%) (Pfizer)	Dust plumage lightly to moderately prn ^{44,538}	Most species, including psittacines, pigeons/ectoparasites	
Pyrimethamine (Fansidar, Roche)	—	<i>Toxoplasma</i> , <i>Atoxoplasma</i> , <i>Sarcocystis</i> ; may be effective for <i>Leucocytozoon</i> ; supplement with folic or folinic acid	
	0.25–0.5 mg/kg PO q12h × 30 days ⁴⁴	Raptors, waterfowl	
	0.5 mg/kg PO q12h × 14–28 days ¹⁰¹	Most species	
	0.5 mg/kg PO q12h × 30 days ⁶⁵	Waterfowl/ <i>Sarcocystis</i>	
	0.5 mg/kg PO q12h × 45 days ⁶³⁵	Psittacines (keas)/ <i>Sarcocystis</i> ; use in combination with amprolium and primaquine	
	0.5–1.0 mg/kg PO q12h × 2–4 days, then 0.25 mg/kg PO q12h × 30 days ²⁶⁸	<i>Sarcocystis</i> ; use in combination with trimethoprim-sulfa 5 mg/kg IM q12h or 30–100 mg/kg PO q12h × 7 days	
	0.5–1.0 mg/kg PO q12h × 30 days ⁴⁵⁹	Eclectus, Amazon parrots/use with trimethoprim-sulfadiazine (30 mg/kg)	
	1 mg/kg feed ⁵⁷³	Game birds	
	100 mg/kg feed ¹⁰¹	Most species	
Quinacrine HCl (Atabrine, Sanofi)	—	Most species/ <i>Atoxoplasma</i> , <i>Plasmodium</i> ; chloroquine and primaquine are preferred; overdosage may cause hepatotoxicity ³⁹²	192
	5–10 mg/kg PO q24h × 7–10 days ^{392,518}	Most species/use higher doses for <i>Lankesterella</i> , <i>Plasmodium</i>	
	7.5 mg/kg PO q24h × 10 days ³⁹²	Most species/ <i>Atoxoplasma</i>	
	26–79 mg/L drinking water × 10–21 days ²³⁵	Pigeons	
Rafoxanide (Flukex, Univet; Ranide, MSD)	10 mg/kg PO ⁶⁶⁴	Raptors/trematodes, cestodes; not available in the United States	193
Resorantel (Terenol-S, Hoechst)	130 mg/kg PO ^{315,396}	Ostriches/cestodes; administer with or without fenbendazole	
Robenidine HCl (Bio-Cox, Hoffmannla Roche)	4–6 mg/kg PO q24h × 6 days ³⁹⁶	Pigeons/prophylaxis of coccidiosis	
	6–10 mg/kg PO q24h × 6–10 days ³⁹⁶	All species	
	4 mg/L drinking water × 7 days ³⁹²	Songbirds	
	10–20 mg/L drinking water × 7 days ^{392,396}	Cockatiels, pigeons	
	100 mg/L drinking water × 3–5 days ^{392,396}	Pigeons	
	33 mg/kg feed ^{396,597}	Chickens	

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Ronidazole (Ronivet-S, Vetafarm)	6–10 mg/kg PO q24h × 6–10 days ³⁹²	Most species	193
	12.5 mg/kg PO × 6 days ⁴⁴	Pigeons	
	60 mg/L drinking water ¹⁶⁷	Finches/ <i>Cochlosoma</i>	194
	100–200 mg/L drinking water × 7 days ³⁹²	Cockatiels, pigeons/higher dosage required for resistant strains in pigeons	
	100 mg/L drinking water × 5–7 days ⁵⁴⁶	Pigeons/flock preventive dose; treatment of choice for <i>Trichomonas</i> ²²⁶	195
	400 mg/L drinking water × 5–7 days ^{143,396,546}	Canaries, pigeons/flock treatment; <i>Trichomonas</i> ; preventive dose ⁵⁴⁶	
	600 mg/L drinking water × 5–7 days ⁵⁴⁶	Pigeons/ <i>Trichomonas</i> ; flock treatment dose	196
	400 mg/kg soft feed ^{143,396}	Canaries	
Rotenone (Ear Miticide, Vedco)	Topical ⁶⁶⁴	<i>Knemidokoptes</i>	
Sulfachlor-pyrazine (Esb3, Vetpac Animal Health)	—	Coccidiostat; drug of choice for <i>Atoxoplasma</i> ; affects the intestinal stages of <i>Atoxoplasma</i> ¹⁴³ ; not available in the United States, but can be obtained through the Bali mynah Species Survival Plan ⁴⁴³	
	1 g of 30% powder/L drinking water × 5 days, off 3 days, on 5 days, then repeat cycle 4×; administer treatment 3× annually ⁴⁴³	Bali mynahs/ <i>Atoxoplasma</i> ; significantly reduced or totally cleared oocyst shedding for extended time; it is uncertain if the drug is safe to use when parents are feeding chicks; supplement with vitamin B ₆	
Sulfachlorpyridazine (Vetisulid, Solvay)	—	Coccidiostat	197
	150–300 mg/L drinking water ¹⁴³	Canaries	
	300 mg/L drinking water × 5 days, off 3 days, on 5 days, then repeat cycle 4×; administer treatment 3× annually ⁴⁴³	Passerines, including Bali mynahs/ <i>Atoxoplasma</i>	198
	300 mg/L drinking water × 7–10 days ²³³	Pigeons	
	400 mg/L drinking water × 30 days ⁵³⁸	Cockatiels, budgerigars/mixture is stable for up to 5 days if refrigerated; change daily; mix well	199
	400–500 mg/L drinking water × 5 days, off 2 days, on 5 days ³⁹²	Most species	
Sulfadimethoxine (12.5%) (Albon, SmithKline)	20 mg/kg PO q12h ⁶⁷	Most species/treatment and prophylaxis of coccidia	200
	25 mg/kg PO q12h × 5 days ⁵³⁸	Most species	
	25–50 mg/kg PO q24h × 3 days ³⁰²	Raptors	201
	25–50 mg/kg PO q24h × 3 days, off 2 days, then q24h × 3 days ²⁷⁰	Raptors	
	50 mg/kg PO once, followed by 25 mg/kg PO q24h × 7–10 days ²⁷⁰	Raptors	202
	50 mg/kg PO q24h × 5 days, off 3 days, on 5 days ⁶¹¹	Psittacines	
	250 mg/kg IM q24h × 3 days, off 2 days, on 3 days ⁶⁶	Pigeons/PD; close to toxic level	203
	330–400 mg/L drinking water × 1 day then 200 mg/L × 4 days ²³³	Pigeons	
	250 mg/L drinking water × 5 days ⁵⁷³	Turkeys	204
	500 mg/L drinking water × 6 days ⁵⁷³	Chickens	
Sulfadimethoxine/ormetoprim (Rofemaid, Hoffmann-La Roche)	10 mg/kg feed ⁵⁷³	Game birds/coccidia, <i>Leucocytozoon</i> , <i>Sarcosporidium</i>	205
	320–525 mg/L drinking water ²³⁴	Poultry	

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Sulfadimidine (33.3%) (Neotrizine, Lilly)	50–150 mg/kg PO, IM q24h × 5–7 days ¹⁹³ 3330–6660 mg (10–20 ml)/L drinking water × 5 days ⁵⁴⁶	Raptors/coccidia; lack of efficacy reported in merlins ¹⁹³ Pigeons/coccidia
Sulfamethazine (Sulmet, Cyanamid)	— 75 mg/kg PO q24h × 3 days, off 2 days, on 3 days ³⁹² 125–185 mg/kg PO q24h × 2 days, then 64–94 mg/kg × 4 days ²⁹³ 125 mg/L drinking water × 3 days, off 2 days, on 3 days ³⁹² 400 mg/L drinking water × 1 day, then 200–270 mg/L × 4 days ²³³	Coccidia Parakeets Chickens Most species Pigeons
Sulfaquinoxaline (Sulquin 6–50, Solvay)	— 100 mg/kg PO q24h × 3 days, off 2 days, on 3 days ³⁹² 225 mg/kg feed continuously ⁵⁷³ 450 mg/kg feed continuously ⁵⁷³ 250 mg/L drinking water × 6 days, off 2 days, on 6 days ⁵³⁸ 400 mg/L (1.4 ml/L) drinking water × 6 days, off 2 days, on 6 days ⁵³⁸ 500 mg/L (1.8 ml/L) drinking water × 6 days, off 2 days, on 6 days ⁵³⁹	Coccidia Lories, pigeons Turkeys Chickens Turkeys Chickens Pigeons
Sulfonamides	—	Contraindicated with dehydration, liver disease, or bone marrow suppression; gastrointestinal upset, regurgitation are common, especially in macaws; use for longer than 2 wk may require vitamin B (folic acid) supplementation
Thiabendazole (TBZ, Omnizole, Thibenzole, Merck)	— 40–100 mg/kg PO q24h × 7 days ³⁹² 50 mg/kg PO, repeat in 14 days ⁴¹⁵ 100 mg/kg PO once, repeat in 10–14 days ⁵⁶⁷ 100 mg/kg PO q24h × 7–10 days ^{293,546} 100–500 mg/kg PO once ³⁹² 250–500 mg/kg PO, repeat in 10–14 days ^{546,611} 425 mg/kg feed × 14 days ^{79,573}	Most species/nematodes, acanthocephalans; generally less efficacious than fenbendazole; may be toxic to cranes, ratites, diving ducks ⁵⁴⁶ Most species Ostriches Raptors Most species/gapeworms, ascarids Most species Most species, including psittacines/ascarids, <i>syngamus</i> Pheasants, cranes
Tinidazole (Fasigyn, Pfizer)	50 mg/kg PO once ³⁹²	Most species/ <i>Giardia</i> , <i>Trichomonas</i> , <i>Entamoeba</i>
Toltrazuril (Baycox, Bayer)	— 7 mg/kg PO q24h × 2–3 days ^{267,302} 10 mg/kg PO q48h × 3 treatments ⁵⁴⁶ 12.5 mg/kg PO q24h × 14 days ⁴⁴³ 15–25 mg/kg PO q24h × 2 days ⁵⁴⁶	Efficacious for refractory coccidiosis; may have some affect on systemic stages of <i>Atoxoplasma</i> ⁴⁴³ ; not very effective against <i>Atoxoplasma</i> when given in water; not available in the United States Budgerigars, raptors Raptors/treatment of choice for coccidiosis Bali mynahs/ <i>Atoxoplasma</i> ; dosage is based on a limited number of clinical cases ⁴⁴³ Raptors

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	20–25 mg/kg PO q7d × 3 treatments ¹⁹³	Raptors/more efficacious than same dose q24h × 2 days	197
	20–35 mg/kg PO once ⁶²⁵	Pigeons/higher dose prevents shedding up to 4 wk; lower dose is minimum dose required to suppress oocyst shedding	
	2 mg/L drinking water × 2 consecutive days per week ¹⁰⁶	Psittacines, passerines, raptors	
	5 mg/L drinking water × 2 days, repeat in 14–21 days ³⁶⁴	Lories/10 mg/L administered during second course of treatment	
	25 mg/L drinking water × 2 days, repeat in 5 days ²²⁵	Geese	
	25 mg/L drinking water × 2 days, repeat in 14–21 days ³⁶⁴	Cockatiels, passerines (goldfinches, manikins, siskins)/coccidia	
	75 mg/L drinking water × 2 days/wk × 4 wk ¹⁰⁹	Canaries	
	75 mg/L drinking water × 5 days ²³⁷	Pigeons	
Trimethoprim/sulfachlorpyridazine (1:5 ratio) (Cosumix Plus, Ciba)	—	See sulfonamides	
	400 mg/kg feed ^{293,519}	Geese	
Trimethoprim/sulfadiazine (Di-Trim, Fort Dodge)	—	See sulfonamides	
	5 mg/kg IM q12h ²⁶⁸	Companion birds/ <i>Sarcocystis</i> ; use in conjunction with pyrimethamine (0.5–1.0 mg/kg PO q12h × 2 days, then 0.25 mg/kg PO q12h × 30 days)	
	30 mg/kg PO q8–12h ^{7,46,270}	Most species, including psittacines, raptors/ <i>Sarcocystis</i> (treat for at least 6 wk); coccidia	
	30–100 mg/kg PO q12h × 7 days ²⁶⁸	<i>Sarcocystis</i> ; use in conjunction with pyrimethamine (0.5–1.0 mg/kg PO q12h × 2 days, then 0.25 mg/kg PO q12h × 30 days)	
	60 mg/kg PO q12h × 3 days, off 2 days, on 3 days ⁴⁴	Raptors, waterfowl/coccidia	
	80 mg/ml drinking water (trimethoprim)/40 mg/ml water (sulfadiazine) ⁶⁴²	Canaries/ <i>Toxoplasma gondii</i>	197
Trimethoprim/sulfamethoxazole (Bactrim, Roche; Septra, Burroughs Wellcome)	25 mg/kg PO q24h ⁵¹⁹	Toucans, mynahs/coccidia	198
	320–525 mg/L drinking water ²³⁴	Poultry/coccidia	198

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TABLE 23 Chemical restraint/anesthetic/analgesic agents used in birds.^{a,b}

Agent	Dosage	Species/Comments
Acepromazine (PromAce, Vedco)	— 0.1–0.2 mg/kg IV ²⁹¹ 0.25–0.50 mg/kg IM ²⁹¹	Phenothiazine tranquilizer; see ketamine for combinations Ratites/most commonly used in combination with other anesthetics; seldom used in other species
α-Chloralose (Sigma Chemical)	— 30 mg/kg PO once ³⁹ 250–430 mg/cup of bait ^{83,340}	Chloral derivative of glucose that depresses cortical centers of the brain ³⁹ ; induces hypothermia ⁴⁹ ; nontreated grain is offered for a few days, and then the bait is provided ¹⁹⁷ Canada geese/immobilization of nuisance geese; prepare a suspension in corn oil, inject into individual bread baits and handtoss to target individuals; onset approximately 60 min, duration up to 24 hr Cranes, American crows, waterfowl (including Canada geese)/immobilization; 160–210 mg per greater sandhill crane; cranes could generally be approached within 1–2 hr of feeding and releasable 8–22 hr later
Alphaxalone/alphadalone (Saffan, Schering-Plough)	— 5–10 mg/kg IM, IV, IP ^{104,344,345,415,546} 12–15 mg/kg IM ¹⁰⁴ 36 mg/kg IM, IP ^{344,345,415}	Steroid anesthetic not available in the United States; see ketamine for combination Most species, including psittacines, pigeons, bustards, cranes, flamingos, waterfowl/short duration (8–10 min) surgical anesthesia; transient apnea may occur Pigeons/duration 20–30 min; useful for radiography Psittacines, waterfowl, raptors/immobilization
Atipamezole (Antisedan, Pfizer)	— 5× medetomidine dose IM, IV ²⁸¹ 0.18–0.28 mg/kg IV ³⁷⁸ 0.25–0.50 mg/kg IM ^{293,379,478,546} 0.25–0.38 mg/kg IM ³⁷⁹ 0.4 mg/kg 1/2 IV, 1/2 SC ³³⁹ 1.3–1.6 mg/kg IV ²⁸²	α ₂ adrenergic antagonist Psittacines, raptors, geese/righting reflex regained 3–10 min after administration Mallard ducks Most species, including psittacines, pigeons Psittacines, mallard ducks Ostriches Chickens
Atracurium besylate (Tracrium, Glaxo Wellcome)	0.15–0.45 mg/kg slow bolus IV ⁴⁴⁰ 0.25–0.46 mg/kg slow bolus IV ³⁷⁰	Chickens/PD; neuromuscular blocking agent with minimal cardiovascular effects; adjunct to general anesthesia to produce muscle relaxation; birds were euthanatized before recovery Chickens/onset of actions, 1–3 min; recovery, 25–45 min
Atropine sulfate (Abbott)	— 0.01–0.02 mg/kg SC, IM, IV ^{5,518} 0.04–1.0 mg/kg SC, IM ⁹⁴ 0.2 mg/kg IM ²⁷⁰	Anticholinergic agent; rarely indicated as a preanesthetic Most species Most species Raptors/bradycardia

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Azaperone (Stresnil, Mallinckrodt)	—	Butyrophenone neuroleptic agent; see metomidate for combination
	0.73 mg/kg IM ⁶¹²	Ratites/sedation
	1 mg/kg IV ⁷²	Ostriches/premedication
	1–4 mg/kg IM ⁷²	Ostriches/sedation
Benzocaine (Trocaine, Roberts)	Topical anesthesia	Small birds/minor wound repair ⁹³
Bupivacaine HCl (Marcaine, Sanofi Winthrop; Sensorcaine, Astra)	—	Local anesthetic agent; 4–6 hr duration of action in mammals ¹¹¹
	2 mg/kg infused SC ³⁸¹	Mallard ducks/PD; high plasma levels at 6 and 12 hr postadministration
	2–10 mg/kg infused into incision site ⁴²³	Eider ducks/bupivacaine toxicity or cumulative toxicity of bupivacaine and ketoprofen may have occurred
	3 mg/0.3 ml saline injected intraarticularly ²⁶²	Chickens/effective for treating musculoskeletal pain
	50:50 mixture with dimethyl sulfoxide applied topically ²¹²	Chickens/topical anesthesia; applied to amputated beaks
Buprenorphine HCl (Buprenex, Reckitt & Colman)	—	Opioid agonist-antagonist ^c ; 0.1–0.5 mg/kg was ineffective for analgesia in most African grey parrots ⁴⁶³
	0.01–0.05 mg/kg IM q8–12h ²⁸⁴	Most species
	0.05–1.0 mg/kg IA ²⁰⁸	Chickens/PD; no effect on pain behavior
	0.25 mg/kg IM q7h ⁴⁶⁴	African grey parrots/PD; analgesic effect needs to be further evaluated at this dose
Butorphanol tartrate (Torbugesic, Fort Dodge)	—	Most species
	0.005–0.25 mg/kg IV ⁶¹⁰	Opioid agonist-antagonist ^c
	0.05–0.40 mg/kg SC, IM q6–8h ⁵³⁹	Ratites
	0.3–1.0 mg/kg IM ²⁷⁰	Pigeons/analgesia; sedation
	0.5–0.75 mg/kg IM q12h ⁵	Raptors; doses > 1 mg/kg may cause recumbency
	0.5–2.0 mg/kg IM q4–6h ^{5,117,284,419,462,463}	Most species/prolonged use
	1 mg/kg IM ^{117,463}	Most species, including psittacines/no isoflurane-sparing effects detected in harlequin ducks when administered IM 15 min before induction ⁴²²
	1 mg/kg IM q24h prn ⁵	African grey parrots (PD), cockatoos (PD)/PD; analgesia; significantly reduced ED ₅₀ of isoflurane ¹¹⁷
	1–4 mg/kg IM q6–12h ^{286,303,462,636}	Most species/prolonged use
		Most species, including raptors, psittacines (African grey parrots, Hispanian Amazon parrots); frequency not to exceed q4h
Butorphanol (B)/ketamine (K)/medetomidine (M)	(B) 1 mg/kg + (K) 3 mg/kg + (M) 40 µg/kg IM ⁶⁵⁴	Psittacines/premedication or supplement to isoflurane; reduces isoflurane requirement and improves ventilation
Carfentanil (Wildnil, Wildlife Pharmaceuticals)	—	Super-potent opioid agonist ^c
	0.024 mg/kg IM ^{396,579}	Ostriches (free-ranging)/darted from helicopter
Carfentanil (C)/xylazine (X)	0.03 mg/kg IM ²⁹¹	Ratites
	(C) 3 mg + (X) 150 mg IM ⁴⁹³	Ostriches (free-ranging)/darted from helicopter
Desflurane (Suprane, Anaquest)	—	Fluorine halogenated ether; fast induction, rapid recovery ²⁵⁰

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Detomidine (Domosedan, Pfizer)	—	α ₂ adrenergic agonist	201
	0.3 mg/kg IM ¹⁰²	Chickens/marked sedation	
Diazepam (Valium, Roche)	—	Benzodiazepine; used alone for sedation, seizure control, tranquilization, and/or appetite stimulation; see ketamine for combinations	202
	0.05–0.15 mg/kg IV ⁵	Most species	
	0.1–0.2 mg/kg IV ⁴⁹⁶	Ratites/smooth anesthetic recovery	
	0.3 mg/kg IV ²⁹¹	Ratites/tranquilization	
	0.2–0.5 mg/kg IM ⁵	Most species/premedication; administer 5–10 min before induction; onset in 15–20 min	
	0.25–0.50 mg/kg IM, IV q24h × 2–3 days ⁵⁸⁹	Raptors/appetite stimulant	
	0.5 mg/kg PO ³⁹⁸	Passerines/calms fractious species while improving acceptance to a novel captive diet; oral solution (1 mg/ml, Roxane Laboratories) works best	
	0.5–0.6 mg/kg IM ^{34,211}	Most species/sedation; facilitates acceptance of Elizabethan collar, especially in lovebirds	
	0.5–1.0 mg/kg IM, IV q8–12h ^{539,546}	Raptors, pigeons, waterfowl/sedation; anticonvulsant	
	1–2 mg/kg IV ³¹⁵	Ostriches/administer just before recovery from Telazol to counter its undesirable effects	
	2.5–4.0 mg/kg PO prn ⁵¹⁹	Most species/sedation	
	5 mg/kg PO ¹⁹⁷	Ostriches/standing sedation	
	5 mg/kg IV ^{197,396}	Emus/rheas/sedation	
	5.5 mg/L drinking water ³⁴	Most species	
Diprenorphine	0.04–0.06 mg/kg IV ^{440,547}	Ostriches/opioid antagonist	
Edrophonium chloride (Tensilon, ICN)	0.5 mg/kg slow bolus IV ⁴⁴⁰	Chickens/PD; neuromuscular blocking agent antagonist	
Etorphine HCl (M-99, Wildlife Pharmaceuticals)	—	Super-potent opioid agonist ^c ; may be inadequate when used as sole agent ²⁹¹	202
	0.025 mg/kg IM ³⁹⁶	Ostriches	
Etorphine (E)/acepromazine (A)	(E) 0.04–0.07 mg/kg + (A) 0.19 mg/kg IM ⁵⁴⁷	Ostriches (10–12 mo of age)	203
	(E) 3.6 mg + (A) 15 mg IM ⁵⁴⁷	Ostriches	
Etorphine (E)/acepromazine (A)/xylazine (X)	(E) 0.04 mg/kg + (A) 0.16 mg/kg + (X) 0.66 mg/kg IM ⁵⁴⁷	Ostriches/sedation for simple procedures lasting 10–20 min	
Etorphine (E)/ketamine (K)	(E) 6–12 mg/bird IM + (K) 200–300 mg/bird IM ²⁹¹	Ostriches (adults)	
Fentanyl citrate (Sublimaze, Taylor)	—	Short-acting opioid agonist ^c	
	0.5–3.0 mg/kg IA ²⁰⁸	Chickens/PD; no effect on pain behavior	
	0.2 mg/kg SC ⁴⁶²	Cockatoos/analgesia; large dose and volume; birds may go through an excitement phase	
Flumazenil (Romazicon, Hoffman-LaRoche)	—	Benzodiazepene antagonist	
	0.018–0.028 mg/kg IV ³⁷⁸	Mallard ducks	
	0.05 mg/kg IM, IV ⁵	Most species	
	0.05 mg/kg intranasal ³⁷⁹	Mallard ducks	
	0.1 mg/kg IM ¹²⁵	Quail/PD; reverses midazolam in 1.4–1.8 min	
Glycopyrrolate (Robinul-V, Aveco)	—	Anticholinergic agent	
	0.01 mg/kg IM, IV ²⁴⁹	Most species/preanesthetic; rarely indicated	
	0.04 mg/kg IV ⁶¹²	Ratites	

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Halothane (Halothane, Rhône Meriéux; Fluothane, Fort Dodge)	0.5%-4.0% induction (increase concentration slowly); 1.5%-3.0% maintenance ¹⁰⁶	Rarely used in birds; hepatotoxic; marked respiratory depression; sensitizes heart to catecholamines causing arrhythmias; slower recovery than isoflurane ^{5,546}	
Isoflurane (Isoflo, Abbott; Aerrane, Anaquest)	— 0.5%-4.0% (usually 1.5%-2%) ⁴⁹	Anesthetic agent of choice in birds ⁵⁶⁴ ; raptors, macaws may be more likely to exhibit isoflurane-induced arrhythmias ^{5,8} ; a dose-dependent decrease in blood pressure has been observed from vasodilation in cranes ⁵ ; reported MAC in cranes and ducks is 1.3% Ostriches/use after preanesthetic medication	203
	1.115% ⁵⁶⁵ 1.44% ± 0.07% ¹¹⁷ 3%-5% ⁴⁹ 3%-5% induction, 1.5%-2.5% maintenance ^{106,476}	Emus/PD; minimum anesthetic concentration Cockatoos/PD; ED ₅₀ Ostriches/when used without preanesthetic medication Most species	204
Ketamine HCl (Ketaset, Fort Dodge/Aveco; Vetalar, Upjohn; Ketalar, Parke-Davis)	— 5 mg/kg IV q10min prn maintenance ²⁹¹ 5–30 mg/kg IM, IV ^{249,546} 5–30 mg/kg PO in bait (≤150 g: 30 mg/kg; 200–400 g: 20 mg/kg; up to 1 kg: 10 mg/kg; ±2 kg: 5 mg/kg) ¹⁹¹ 11.1 mg/kg IM ³⁹⁶ 15–25 mg/kg IM, IV ²⁴⁹ 20–50 mg/kg SC, IM, IV ^{45,291,344,546} 25 mg/kg IM ^{291,396} 50 mg/kg IM ¹⁹⁷ 50–100 mg/kg PO in bait ^{44,107,546}	Dissociative anesthetic; seldom used as sole agent because of poor muscle relaxation and prolonged (up to 3 hr), violent recovery ⁵⁵⁹ ; may produce excitation or convulsions in pigeons, gallinules, water rails, golden pheasants, Hartlaub's turaco, ratites, and vultures ^{291,548} ; may fail to produce general anesthesia in some species, including great horned owls, snowy owls, Cooper's hawks, sharp-shinned hawks, and waterfowl ⁵ Ketamine combinations follow Ratites Raptors/sedation Ducks/sedation; may be used to catch ducks on a pond Ostriches Waterfowl Psittacines, pigeons, ratites, waterfowl/restraint 30–60 min; smaller species require a higher dose; large birds tend to recover more slowly Emus/may need to supplement 5–9 mg/kg IV q10min Poultry Raptors/sedation to catch an escaped bird; place in a 30 g piece of meat	204
Ketamine (K)/acepromazine (A)	(K) 10–25 mg/kg + (A) 0.5–1.0 mg/kg IM ^{117,636} (K) 25–50 mg/kg + (A) 0.5–1.0 mg/kg IM ⁶³⁶	Most species/high dose for birds <250 g Psittacines	205

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Ketamine (K)/diazepam (D)	(K) 2–5 mg/kg IV + (D) 0.25 mg/kg IV ⁷²	Ostriches/ketamine may be given 15–30 min after diazepam ¹¹¹
	(K) 3–8 mg/kg + (D) 0.5–1.0 mg/kg IM ²⁵³	Eagles, vultures
	(K) 5–10 mg/kg + (D) 0.1–0.2 mg/kg IV ⁵³⁸	Ratites/induction
	(K) 5–25 mg/kg + (D) 0.5–2.0 mg/kg IV ⁶³⁶	Psittacines/lower end of range is preferred
	(K) 5–30 mg/kg IM + (D) 0.5–2.0 mg/kg IM, IV ⁴⁹	Most species
	(K) 8–15 mg/kg + (D) 0.5–1.0 mg/kg IM ²⁵³	Falcons
	(K) 10–25 mg/kg + (D) 0.5–1.0 mg/kg IM, IV ⁵³⁹	Pigeons/lower end of range administered IV is preferred; useful for oral procedures
	(K) 10–40 mg/kg IV + (D) 1.0–1.5 mg/kg IM, IV ^{345,510}	Raptors, waterfowl/induction or surgical anesthesia (rapid bolus may produce apnea, arrhythmia, and increased risk of death)
	(K) 10–50 mg/kg + (D) 0.5–2.0 mg/kg IM ⁶³⁶	Psittacines/improved muscle relaxation over ketamine alone
	(K) 20 mg/kg + (D) 1 mg/kg IV ¹¹⁵	Toucans/short procedures (15–20 min)
Ketamine (K)/medetomidine (M)	—	Unreliable level of sedation in pigeons at (K) 5 mg/kg/(M) 80 µg/kg IM ⁴⁷⁸
	(K) 1.5–2.0 mg/kg + (M) 60–85 µg/kg IM, IV ^{83,345}	Pigeons, waterfowl/sedation
	(K) 2 mg/kg + (M) 80 µg/kg IM ³³⁹	Ostriches/sedation
	(K) 2–4 mg/kg + (M) 25–75 µg/kg IV ²⁸¹	Raptors
	(K) 2.5–7.0 mg/kg + (M) 50–100 µg/kg IV ²⁸⁰	Large psittacines
Ketamine (K)/medetomidine (Me)/midazolam (Mi)	(K) 3–5 mg/kg + (M) 50–100 µg/kg IM ²⁸¹	Raptors
	(K) 3–7 mg/kg + (M) 75–150 µg/kg IM ²⁸⁰	Large psittacines
	(K) 5–10 mg/kg + (M) 100–200 µg/kg IM, IV ²⁸¹	Geese
	(K) 25 mg/kg + (M) 100 µg/kg IM ⁵¹⁴	Psittacines/anesthesia
	(K) 10 mg/kg + (Me) 50 µg/kg + (Mi) 2 mg/kg IV ^{378,379}	Mallard ducks/PD; anesthesia of 30 min duration; reverse with atipamezole, flumazenil (intranasal); regimen considered unsafe because of acidosis, bradypnea, apnea (3 of 12 birds required resuscitation), and, in 1 of 12 birds, death ³⁷⁹
Ketamine (K)/midazolam (M)	(K) 10–40 mg/kg + (M) 0.2–2.0 mg/kg SC, IM ^{390,396,636}	Most species, including psittacines
	(K) 20 mg/kg + (M) 4 mg/kg IM ¹⁰⁶	Psittacines/anesthesia
Ketamine (K)/midazolam (M)/butorphanol (B)	(M) 0.2 mg/kg + (B) 0.4 mg/kg IM followed by (K) 8.69 ± 0.51 mg/kg IV ³⁰	Ostriches/PD; anesthesia; followed by intubation and isoflurane anesthesia
Ketamine (K)/tiletamine/zolazepam (T)	(K) 15 mg/kg + (T) 10 mg/kg IM ³³³	Waterfowl/anesthesia

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Ketamine (K)/xylazine (X)	—	Associated with cardiac depressive effects and rough recoveries; allometrically scaled dosages for waterfowl are available ³¹²	
(K) 0.45 mg/kg + (X) 25 mg/kg IM ³⁹⁶		Ostriches	
(K) 2–3 mg/kg IV + (X) 5–10 mg/kg IM ⁷²		Ostriches	
(K) 2–5 mg/kg IV + (X) 0.25 mg/kg IV ⁷²		Ostriches	
(K) 2.2–3.3 mg/kg + (X) 2.2 mg/kg IM ²⁹¹		Ratites/administer xylazine 10–15 min before ketamine	206
(K) 4.4 mg/kg + (X) 2.2 mg/kg IV ^{270,344}		Psittacines, raptors	207
(K) 5 mg/kg + (X) 0.5–1.0 mg/kg IV ³¹²		Ostriches/xylazine should precede ketamine	
(K) 5 mg/kg + (X) 1 mg/kg IM ⁴⁹		Ostriches	
(K) 10 mg/kg + (X) 0.5–1.0 mg/kg IM ^{13,400}		Ratites, turkey vultures	
(K) 10–15 mg/kg + (X) 2 mg/kg ^{197,421}		Owls	
(K) 10–50 mg/kg + (X) 1–10 mg/kg IM ^{111,421}		Psittacines/birds <250 g require a dose at the higher end of the range	
(K) 15–20 mg/kg + (X) 1.5 mg/kg IM ⁴²¹		African grey parrots	
(K) 20 mg/kg + (X) 1 mg/kg IV ^{115,369}		Pekin ducks, toucans/bradypnea, acidemia, hypoxemia, moderate hyperthermia observed in ducks; (X) 1–2 mg/kg IV in toucans	
(K) 20 mg/kg + (X) 1–2 mg/kg IV slow bolus ¹¹⁵		Toucans	
(K) 20–30 mg/kg + (X) 2.5–4.0 mg/kg IM ^{106,421}		Psittacines/in cockatoos, use (X) 2.5–3.5 mg/kg	
(K) 25 mg/kg + (X) 1 mg/kg IM ⁶⁰⁰		Guinea fowl/clinical trial	
(K) 25 mg/kg + (X) 2.5 mg/kg IM ⁴²¹		Cockatiels	
(K) 25–30 mg/kg + (X) 2 mg/kg IM ⁴²¹		Falcons, hawks	
(K) 30–40 mg/kg + (X) 6.5–10 mg/kg IM ^{251,421}		Budgerigars	
Ketamine (K)/xylazine (X)/acepromazine (A)	(K) 34 mg/kg + (X) 0.2 mg/kg + (A) 0.1 mg/kg IM ²⁹¹	Ostriches	
Ketamine (K)/xylazine (X)/alfaxalone/alfadolone (A)	(K) 5mg/kg + (X) 1 mg/kg + (A) 12–17 mg/kg IV ³⁹⁶	Ostriches	
Lidocaine (Xylocaine, Astra)	—	Local anesthetic agent with a duration of action in mammals of 90–200 min ¹¹¹ ; 4 mg/kg or higher may lead to seizures and death ^{270,462} ; dilute at least 1:10 in small birds	
	1–3 mg/kg ^{5,270,462}	Most species	207

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Medetomidine (Domitor, Pfizer)	—	α_2 adrenergic agonist; 80–2000 $\mu\text{g/kg}$ IM was associated with inadequate sedation in the pigeon ^{478,551} ; 100 $\mu\text{g/kg}$ IM did not immobilize ostrich chicks ⁶²² ; see ketamine and butorphanol for combinations Psittacines Raptors Chickens/sedation; 60 μg given to male birds, 40 μg given to female birds; average time of sedation was 6 min	208
	60–85 $\mu\text{g/kg}$ IM ⁵⁴⁶ 150–350 $\mu\text{g/kg}$ IM ⁵⁴⁶ 250–350 $\mu\text{g/kg}$ PO ²⁸²		
Meperidine HCl (Demerol, Sanofi Winthrop)	— 1–4 mg/kg IM ^{519,612}	Short-acting opioid agonist ^C Most species, including ratites (at 1 mg/kg)/sedation; analgesia	
Methohexital sodium (Brevital, Jones)	— 4–8 mg/kg IV ³⁹⁶ 5–10 mg/kg IV ³⁹⁶	Rapid, ultra-short-acting barbiturate anesthetic Poultry Ducks	
Metomidate HCl (or methoxymol) (Hypnodil, Krka; Aquacalm, Syndel)	15–20 mg/kg IM ³¹⁵ 4 g/cup of bait (usually corn) ³⁹⁶	Ostriches/with or without azaperone Wild turkeys	
Metomidate (M)/azaperone (A)	(M) 10–20 mg/kg + (A) 3.3–6.6 mg/kg IM ^{396,622}	Ostriches, including chicks	
Midazolam (Versed, Roche; Hypnovel, Roche)	— 0.05–0.15 mg/kg IV ⁵ 0.1–0.5 mg/kg IM ⁵ 0.15 mg/kg IV ²⁹¹ 0.2 mg/kg SC, IM ⁵⁴⁶ 0.3–0.4 mg/kg IM ^{291,400} 0.4 mg/kg IV ²⁹¹ 0.5–1.0 mg/kg IM, IV q8h ⁴⁴ 0.8 mg/kg IM, IV ²⁴⁹	See ketamine for combinations Most species Most species/premedication; onset in 5–15 min Ostriches/rapid sternal recumbency in adults Psittacines/for use in combination with ketamine Ostriches, emus/premedication; sedation of adult emus Emus Raptors/sedation Most species/birds>500 g	208
	1.5 mg/kg IM, IV ²⁴⁹ 2 mg/kg IM ⁶¹⁸ 2–3 mg/kg IM ²⁹³ 2–6 mg/kg IM ¹²⁵ 4–6 mg/kg IM ²⁹³	Most species/birds <500 g Canada geese/sedation for 15–20 min Amazon parrots Quail/PD; mild to heavy sedation Waterfowl	209
Morphine sulfate (Astromorph, Astra)	— 1–3 mg/kg intraarticular ²⁰⁸ 2.5–3.0 mg/kg SC, IM q4h ⁵²⁰ 200 mg/kg IV ⁴⁶²	Opioid agonist ^C Chickens/PD; no effect on pain behavior Galliformes/analgesia Chicks/no analgesic effects observed	
Naloxone HCl (Narcan, DuPont)	— 0.01 mg/kg IV ³⁰ 2 mg IV q14–12h ^{518,611}	Opioid antagonist Ostriches Most species, including psittacines	
Naltrexone (Trexonil, Wildlife Pharmaceuticals)	300–330 mg IM, IV ^{315,396,493}	Ostriches/opioid antagonist	

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Nitrous oxide (N)	—	Sufficient oxygen must be provided to avoid hypoxic mixtures; may cause some cardiovascular depression ²⁵⁰ ; do not use in birds with normal subcutaneous air pockets (e.g., pelicans, hornbills) or in birds with marginal respiratory reserves ^{5,250} Raptors/intraoperative analgesia	
	Delivered with isoflurane in a 40%N/60% oxygen mixture at a flow rate of 1 L/min ⁵¹⁵		
Nitrous oxide (N)/isoflurane (I)/vecuronium (V)	0.3 L/kg/min of oxygen and (N) (1:1, min 33% O ₂) + (I) 1.0%-2.4% + (V) 0.2 mg/kg IV ^{327,328}	Most species/mydriasis and anesthesia; gases are administered by air sac cannulation; vecuronium effective up to 256 min in pigeons	
Pentobarbital sodium (Nembutol, Abbott)	— 13.3 mg/kg IV ³⁹⁶	Short-acting barbiturate Emus/premedicate with diazepam	
Phenobarbital (Phenobarbital Sodium, Wyeth-Ayerst)	1–7 mg/kg PO q8–12h ²¹⁴	Most species/mild sedative effect; see psychotropic agents for other indications	209
Propofol (Rapinovet, Mallinckrodt; Diprivan, Stuart)	— 1.33 mg/kg IV ^{270,546} 2.89–4.73 mg/kg IV (induction); 0.42–0.54 mg/kg/min IV (maintenance) ²⁴⁸ 3 mg/kg IV (induction); 0.2 mg/kg/min IV (maintenance) ³³⁹ 4 mg/kg IV (induction); 0.5 mg/kg/min IV (maintenance) ³⁸⁹ 5 mg/kg IV (induction); 1 mg/kg/min IV (maintenance) ³⁴² 5 mg/kg IV (induction); 0.5 mg/kg/min IV (maintenance) ⁵⁵⁷ 8–10 mg/kg IV (induction); 1–4 mg/kg IV boluses prn (maintenance) ^{378–380} 14 mg/kg IV ^{170,270} 20 mg/kg IV (induction); 3 mg/kg IV boluses prn (maintenance) ³⁸⁰	IV sedative-hypnotic agent; intubation, ventilation, and supplemental oxygen are strongly recommended ^{5,380,557} Psittacines, raptors Red-tailed hawks/prolonged recovery period may occur Ostriches/PD; anesthesia Barn owls/anesthesia Adult Hispaniolan parrots/PD; light anesthesia Wild turkeys/PD; anesthesia Mallard ducks (PD); canvasback ducks (PD)/anesthesia Pigeons, raptors/anesthesia; 2–7 min duration; severe respiratory depression and apnea documented in pigeons Canvasback ducks/PD; anesthesia	210
Sevoflurane (Ultane, Abbott)	Incremental increases up to 7% prn (induction) ⁴⁸⁸ 2.21% ± 0.32 ⁴³³	Psittacines/anesthesia; similar to isoflurane; provides more rapid recovery; less incidence of ataxia during recovery ^{250,327,488} Chickens/PD; minimum anesthetic concentration; dose-dependent decrease in arterial pressure	
Thiopental (Pentothal, Abbott)	— 5.5–11 mg/kg IV ⁴⁷⁶	Ultra-short-acting barbiturate Ostriches	
Tiletamine/zolazepam (Telazol, Fort Dodge)	— 1–8 mg/kg IV ^{291,421}	Dissociative anesthetic associated with prolonged, rough recoveries ⁵ Ratite adults/induction and/or short procedures	210

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	2–12 mg/kg IM ^{197,360,396,584}	Ratites (adults)/induction and/or short procedures ¹⁹⁷ ; recommend 3–5 mg/kg IM for captive birds and 5 mg/kg IM for free-ranging birds	211
	4–25 mg/kg IM ^{107,554,622}	Most species, including psittacines, raptors, ostriches, flamingos, waterfowl/sedation; dose generally decreases as body weight increases in waterfowl	
	5–10 mg/kg IM ^{44,270,315,333,344,345}	Ostriches (chicks), raptors	
	6.6 mg/kg IM ⁵⁵⁴	Swans	
	9–30 mg/kg IM ⁵⁵⁴	Owls, wood partridges/restraint	
	10 mg/kg IM ^{333,554}	Raptors	
	10–30 mg/kg IM ²⁴²	Most species/restraint; anesthesia; moderate analgesia	
	15–22 mg/kg IM ^{415,421,554}	Budgerigars, emus	
	40–80 mg/kg PO ¹⁰⁷	Raptors	
	80 mg/kg in feed ^{283,658}	Eurasian buzzards/sufficient in most birds to allow safe handling after 30–60 min; birds receiving drug in powder form reached a deeper plane of anesthesia quicker	
Tolazoline chlorhydrate (Priscoline, Ciba-Geigy)	—	α_2 adrenergic antagonist	
	1 mg/kg IV ³¹⁵	Ostriches	
	15 mg/kg IV ^{13,396}	Raptors, including vultures ¹⁰²	
Tribromoethanol (Avertin)	1266 mg/kg whole corn ⁹⁰	Waterfowl/safest and most effective agent given in feed to immobilize waterfowl; dissolve agent in water, then pour it on corn in a shallow container and allow rapid drying with a fan	
	12,000 mg/kg grain ¹⁹⁷	Granivores	
Xylazine (Rompun, Bayer)	—	α_2 adrenergic agonist seldom used in pet birds; adverse effects may include excitement, convulsions, bradycardia, arrhythmias, bradypnea, hypoxemia, hypercarbia, and death when used alone ^{250,548}	
	0.2–1.0 mg/kg IM ^{291,493}	Ratites/calming sedation	211
	1 mg/kg IV ³⁶⁹	Ducks	212
	1.0–2.2 mg/kg IM, IV ⁵⁴⁶	Raptors, psittacines, ratites (IM)/heavy sedation	
	1–20 mg/kg IM, IV ^{83,270}	Waterfowl, raptors/sedation	
Xylazine (X)/butorphanol (B)	(X) 1.06–2.75 mg/kg + (B) 0.10–0.55 mg/kg IM ³⁶⁰	Ratites, including rheas/sedation, premedication; higher doses were needed in rheas	
Yohimbine (Yobine, Lloyd)	—	α_2 adrenergic antagonist; excitement and mortality observed at doses > 1 mg/kg ²⁵⁰	
	0.1–0.2 mg/kg IV ^{83,546}	Psittacines, raptors, waterfowl	
	0.1–0.2 mg/kg IM, IV ^{270,415}	Raptors	
	0.11–0.275 mg/kg IM once ²⁵¹	Budgerigars	
	0.1–1.0 mg/kg ⁵	Most species	
	0.125 mg/kg IV ^{291,315,493}	Ratites	
	1.0 mg/kg IV ⁶⁰⁰	Most species including psittacines, guinea fowl	
a For other analgesic recommendations, refer to Tables 24 (hormones and steroids) and 25 (nonsteroidal antiinflammatory agents).			
b The anesthetic agents of choice in most avian species are the inhalent agents, isoflurane and sevoflurane.			

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- c All opioid agonists and agonist-antagonists may cause respiratory depression; profound bradypnea may occur with potent opioid agonists.

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TABLE 24 Hormones and steroids used in birds.

Agent	Dosage	Species/Comments
Adrenocorticotrophic hormone (ACTH) (Acthar, Amour; ACTH, Parke-Davis)	1–2 IU/kg IM ⁵³⁵ 16–26 IU/bird IM ⁶¹¹ 16 IU/bird IM ^{366,494,610,659} 50–125 µg/bird IM ⁵¹⁸	Psittacines/ACTH stimulation test Obtain baseline sample, administer ACTH, then sample in 1–2 hr; stress of handling and venipuncture may invalidate results Psittacines, including Amazon parrots, cockatoos, conures, lorikeets, macaws Pigeons
Boldenone undecylenate (Equipoise, Solvay)	1.1 mg/kg IM q21d ⁶¹²	Ratites/anabolic steroid
Calcitonin (Salmonine, Lennod; Micalcin, Sandoz)	4 IU/kg IM q12h × 14 days ⁵¹⁹	Most species/hypercalcemia (caused by cholecalciferol rodenticide toxicity)
Chorionic gonadotropin (hCG, Pregnyl Organon)	500–1000 IU/kg IM on day 1, 3, 7 q3–6wk prn ^{41,355,356,611} 500–1500 IU/kg IM q14d or prn ²⁸⁷	Most species/inhibits egg laying; administer on days 3 and 7 if hen lays after day 1 Most species/inhibits egg laying
Dexamethasone (Azium, Schering-Plough) ^a	0.2–1.0 mg/kg IM, IV once or q12–24h × 2–7 days, then q48h × 5 days ^{270,402} 2–4 mg/kg IM, IV q12–24h ^{34,68,611} 2–8 mg/kg SC, IM, IV q12–24h ⁴⁴⁶ 3 mg/kg IM, IV ³⁴	Most species, including raptors/antiinflammatory Most species, including ratites/shock, trauma Cranes/reduce doses for long-term therapy Owls, hawks/PD; antiinflammatory; trauma; shock; enterotoxemia; one dose suppressed plasma corticosterone levels for 18 hr in hawks
Dexamethasone sodium phosphate (Dexaject SP, Vetus) ^a	2–4 mg/kg SC, IM, IV q6h–24h ^{303,542}	Most species, including raptors/head trauma, shock, hyperthermia; higher dose for shock, head trauma, and endotoxemia
Diethylstilbestrol diphosphate (Stilphostrol, Bayer)	0.025–0.075 mg/kg IM ^{396,610} 0.4 mg/L drinking water ⁵¹⁸	Most species/narrow therapeutic index Most species
Dinoprost tromethamine	—	See prostaglandin F _{2α}
Dinoprostone	—	See prostaglandin E _{2α}
Ergonovine maleate (Lilly)	0.06 mg/kg IM once ⁵¹⁸	Most species/administered with or without calcium for egg binding
Estradiol benzoate (Estradiol Cypionate, ECP, Pharmacia)	— 0.3–0.5 mg/kg PO q24h × 1 mo ²⁵⁹ 1 mg/kg IM q24h × 12 days ²⁵⁹ 10–15 mg/kg IM q7d × 4 treatments ²⁵⁹	Estrogens have been associated with severe adverse reactions in mammals ⁴⁷³ ; anemia, hypercholesterolemia, and hyperlipidemia were observed in penguins ²⁵⁹ Penguins/induces molt Mallard ducks/induces molt Penguins/induces molt
Fludrocortisone (Florinef Acetate, Apoticon)	0.4 mg/L drinking water ⁵³⁵	Adrenal replacement surgery
Flumethasone (Flucort, Syntex) ^a	1.0–1.5 mg/kg PO, SC, IM, IV ⁶¹²	Ratites/glucocorticoid; inflammation
Goserelin acetate (Zoladex, Zeneca)	3600 µg implant SC × 30 days ²⁵⁹	GnRH agonist; unsuccessful in inducing molt in penguins

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Hydrocortisone (Sodium Succinate; Hoffman) ^a	3.0–4.5 mg/kg PO q12h ⁶¹² 10 mg/kg IM q24h ⁶¹⁰ 10 mg/kg IV ¹⁰⁶ 40–50 mg/kg IV q24h ⁶¹²	Ratites Psittacines/hypoadrenocorticism Psittacines, passerines, raptors Ratites	214
Insulin	0.002 IU/bird IM q12–48h ⁶⁵² 0.01–0.10 IU/bird IM q12–48h ⁴⁹⁴ 0.1–0.5 IU/bird IM daily or intermittently ⁶⁵³ 0.5–3.0 IU/kg IM ⁶¹¹ 1.4 IU/kg IM q12–24h ^{293,519} 2 IU/bird IM ^{427,611}	Budgerigars/NPH insulin Amazon parrots/NPH insulin Toucans (toco) Psittacines/NPH insulin Cockatiels, toco toucans/NPH insulin Toco toucans/ultralente or PZI insulin; adjust dose or frequency based on glucose curves	
Leuprolide acetate (Lupron Depot, TAP Pharmaceuticals; Lupron Kit, Florida Infusion Pharmacy; single-dose leuprolide acetate available from Professional Arts Pharmacy, 9285) Baltimore, MD, 800–832–	— 100 µg/kg q14d for 3 treatments ^{211,287} 200–800 µg/kg IM q3–6 wk ²⁹⁵ 500 µg/kg IM q14d ⁶⁵⁷ 700–800 µg/kg IM q14d ⁵⁸ 375 µg/bird IM ^{271,411} 750 µg/kg IM q14d ⁶⁵⁷ 800 µg/kg IM ³²⁰ 1250 µg/kg IM once ²⁵⁹ (no. of days for desired effect) × (52 or 156 µg/kg) = dosage IM ⁴¹⁰	Synthetic GnRH agonist depot drug; prevents ovulation, may be indicated in some cases of sexually related feather picking or mutilation ²¹¹ ; variable results obtained; in treating reproductive diseases, administration before onset of egg laying may be more successful than treatment during breeding Most species Most species Psittacines (≥300 g)/for most problems, begin with 3 treatments Psittacines Cockatiels/inhibit ovulation Psittacines (<300 g)/for most problems, begin with 3 treatments Hispaniolan Amazon parrots/hormonal effects may taper off between 7 and 21 days after administration Penguins/induced molt in 1 of 2 birds dosed Cockatiels	215
Levonorgestrel depot form (Levonorgestrel, Sigma Chemical)	40 mg/kg SC (repeat in 60 days in turkeys) ^{186,603}	Japanese quail, turkeys/halts egg laying	
Levothyroxine (l-thyroxine) (Synthroid, Knoll; Soloxine, JPI Jones)	— 5–200 µg/kg PO q12h ⁵³³ 20 µg/kg PO q12–24h ^{494,611} 20–100 µg/kg PO q12h ^{546,578}	May induce molt; monitor blood levels and BW Amazon parrots Most species, including psittacines Psittacines	215

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	<p>100 µg/bird PO 2x/wk⁷²</p> <p>200–400 µg/bird PO q24h × 14 days⁵⁹⁶</p> <p>200–1000 µg/kg PO q24h × 14 days¹⁰⁷</p> <p>BW 750–1000 g;</p> <p>25 µg q24h × 7 days</p> <p>50 µg q24h × 7 days</p> <p>75 µg q24h × 7 days</p> <p>50 µg q24h × 7 days</p> <p>25 µg q24h × 7 days²⁷⁰</p> <p>280–830 µg/L drinking water (100 µg/120–360 ml) (mixed fresh daily for 5–10 days)^{494,611}</p>	<p>Ostriches (<60 days of age)</p> <p>Chickens/induces molt; reduces egg laying</p> <p>Raptors</p> <p>Raptors/stimulates molt; scale dose up or down by up to 50% for larger or smaller birds</p> <p>Most species</p>	216
Medroxyprogesterone acetate (Depo-Provera, Upjohn)	—	<p>This agent is not recommended; previously used for sexually related feather picking or chronic egg laying; high incidence of adverse effects, including lethargy, polydipsia, polyphagia, polyuria, immunosuppression, weight gain, liver disease, thromboembolism, diabetes mellitus, salpingitis, sudden death²¹¹</p> <p>Psittacines/suppress ovulation; antipruritic (feather picking in male parrots)</p> <p>Psittacines/higher dosages recommended for smaller birds (e.g., 50 mg/kg for 150 g bird)³⁹⁶</p> <p>Penguins/induces molt 60–90 days after injection</p> <p>Most species</p> <p>Pigeons/inhibits ovulation</p>	216
Megestrol acetate (Ovaban, Schering)	—	<p>Progestin providing nonspecific calming effects⁵⁶; side effects can be severe (diabetic-like); seldom used</p> <p>Psittacines/feather picking; sexual behavior problems</p> <p>Most species/feather picking</p>	216
Methylprednisolone acetate (Depo-Medrol, Upjohn) ^a	<p>0.5–1.0 mg/kg PO, IM^{518,610,611}</p> <p>200 mg/bird IM, repeat prn⁶¹²</p>	<p>Most species/allergies (Amazon foot necrosis)⁵¹⁸; use orally once weekly, then taper to once monthly, then stop</p> <p>Ratites (adults)</p>	217
Mibolerone (Cheque Drops, Upjohn)	—	<p>Potent anabolic and androgenic steroid</p> <p>Psittacines/feather picking</p>	
Nandrolene laurate (Laurabolin, Intervet)	—	<p>Testosterone derivative/used in the treatment of chronic, debilitating disease; may be hepatotoxic</p> <p>Most species</p> <p>Psittacines, raptors, bustards</p>	

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Oxytocin (Oxytocin, Butler)	—	Use of oxytocin should be preceded by calcium administration for egg binding; contraindicated unless uterovaginal sphincter is well dilated and uterus is free of adhesions; used alone to stop uterine bleeding ⁵²⁹ Psittacines/egg binding and dystocia	
	0.5 IU/kg; may be repeated in 60 min ⁵⁴² 2 IU/kg IM ⁵⁷⁸ 3–5 IU/kg IM, may repeat q30min ^{44,546} 5–10 IU/kg IM once ⁵⁷⁰ 20–30 IU/bird IM q24h × 2 treatments ⁶¹²	Psittacines Most species, including waterfowl, raptors Psittacines/in some cases, multiple injections are recommended Ratites (adults)/egg binding	
Prednisolone (prednisone) (Pediapred, Fisons) ^a	0.5–1.0 mg/kg IM, IV once ⁵¹⁸ 1.0–1.25 mg/kg PO q48h ⁶¹² 2 mg/kg PO q12h ⁴⁵ 2 mg/kg IM, IV q12–24h ⁴⁴⁶ 2–4 mg/kg IM, IV ²⁷⁰	Most species Ratites Psittacines/inflammation Cranes/shock, trauma, chronic lameness Raptors/shock	217
Prednisolone sodium succinate (Solu-Delta-Cortef, Upjohn) ^a	0.5–1.0 mg/kg IM, IV ⁵⁴² 2–4 mg/kg IM, IV once ⁵⁴² 1.5–2.0 mg/kg IM q12h ⁶¹² 5.0–8.5 mg/kg IV q1h ⁶¹² 10–20 mg/kg IM, IV q15min prn ⁹⁴ 30 mg/kg IV, then 15 mg/kg IV at 2 and 6 hr, then 2.5 mg/kg/hr × 24 hr ⁴⁰	Psittacines/antiinflammatory Psittacines/shock; trauma; endotoxemia; immunosuppression Ratites/immunosuppression (see prednisolone for prolonged therapy) Ratites/shock Most species/head trauma; cardiopulmonary resuscitation Most species/neurologic emergencies; start therapy within 4 hr of trauma	218
Prednisone	—	See prednisolone	
Prostaglandin E ₂ (dinoprostone) (Prepidil Gel, Upjohn)	0.02–0.1 mg/kg applied topically to the uterovaginal sphincter ^{44,271,529,542} 1 ml/kg applied topically to the uterovaginal sphincter ⁶¹¹	Most species, including psittacines, raptors, waterfowl/dystocia; relaxes uterovaginal sphincter; lower dosage may be effective; freeze into aliquots Psittacines	
Prostaglandin F _{2α} (Dinoprost tromethamine) (Lutalyse, Upjohn)	0.02–0.1 mg/kg IM, intracloacal once ^{546,610,611}	Most species, including psittacines, raptors, and waterfowl/dystocia; may be helpful when the egg is located distally and the uterovaginal sphincter is dilated; can result in uterine rupture, bronchoconstriction, hypertension, death	
Somatostatin (Sandostatin, Sandoz)	0.003 mg/kg SC q12h ³⁰⁹	Toucans (sulfur-breasted)/diabetes mellitus (clinical improvement observed; hyperglycemia and elevated glucagon levels persisted)	
Stanozolol (Winstrol V, Upjohn)	— 0.5–1.0 mg/kg IM ⁴⁰² 25–50 mg/kg IM q3–7d ^{396,546,610} 17 mg/L drinking water ⁴⁰²	Anabolic steroid Most species Most species Most species	218
Tamoxifen citrate (Nolvadex, Zeneca; Tamofen, Rhône-Poulenc Rorer Canada, Inc)	— 2 mg/kg PO q24h given on 2 consecutive days per wk for 38–46 wk ³⁷⁷ 40 mg/kg IM ^{259,574}	Nonsteroidal antiestrogen Budgerigars/effects suggested by change in cere color from white/brown to blue; leukopenia was the most significant adverse effect ³⁷⁷ Galliformes, ducks, penguins/induces molt	219

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Testosterone (Testandro, Redur; Tesamone, Dunhall)	—	Anabolic steroid; may adversely affect spermatogenesis; contraindicated with hepatic or renal disease ¹⁰⁵
	2–8 mg/kg SC, IM once ¹⁰⁵	Most species/stimulates sexual behavior in the male; baldness in canaries
	8.0–8.5 mg/kg IM q7d prn ¹¹	Most species, including psittacines, canaries ⁵⁴⁶ /anemia, libido, debilitation
	10–15 ml stock solution/L drinking water × 5 days–2 mo ⁵³⁸	Canaries/finish molt or regain singing; stock solution: 100 mg parenteral suspension/30 ml drinking water (3333 mg/L); mix fresh daily
Thyroid releasing hormone	15 µg/kg IM once ¹⁰⁵	Most species
Thyroid stimulating hormone (TSH) (thyrotropin) (Thyrogen, Genzyme Corp; Dermathycin, Coopers; Thyrotropar, Armour)	0.1 IU IM ⁴⁹⁴	Cockatiels
	0.2 IU/kg IM ²¹⁹	Macaws/PD; T ₄ doubled in 6 of 11 birds 4 hr after receiving TSH
	1 IU/kg IM ^{219,494,659}	Hispaniolan parrots, blue-fronted Amazon parrots, African grey parrots, pigeons/PD; T ₄ doubled in Hispaniolan parrots and blue-fronted parrots 6 hr after receiving TSH
	1–2 IU/kg IM ^{518,611}	Psittacines/obtain blood at 0 hr, then 4–6 hr after TSH stimulation
Triamcinolone (Vetalog, Fort Dodge) ^a	0.1–0.5 mg/kg IM once ^{270,610}	Most species/including raptors
Administration may also be associated with the development of polyuria/polydypsia/polyphagia, increased protein catabolism, glucosuria, and diabetes mellitus.		
Toxic levels may be attained even with topical application. ²⁵⁷ Administration should ideally not exceed 5 days. Alternate-day application of topical corticosteroids at double the daily dose is recommended if the drugs must be given long term. Rapid onset, shorter-acting drugs are generally less likely to cause serious adverse effects. ²⁵⁸		

^a Steroid administration may predispose birds to aspergillosis and other mycoses.²⁷⁰

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TABLE 25 Nonsteroidal antiinflammatory agents used in birds.^{a,b}

Agent	Dosage	Species/Comments
Acetaminophen (Tylenol, McNeil)	5 mg/L drinking water ⁶¹⁰	Most species/antipyretic, analgesic; overdosage may be associated with hepatotoxicity
Aspirin (acetylsalicylic acid) (Children's aspirin, Bayer)	— 0.5–1.0 mg/kg PO q12h ⁶⁵⁶ 5 mg/kg PO q8h ^{519,610,611} 10 mg/kg PO q24h × 3 days ⁵³⁸ 150 mg/kg PO ⁴²⁹ 1200–1300 mg/L drinking water (5 grains or 325 mg/250 ml) ^{396,636}	Uricosuric; contraindicated with tetracycline, insulin, or allopurinol therapy ⁴ Amazon parrots Most species Most species Psittacines Most species ⁴⁶² /make fresh q8–48h; alters taste of water (may not be well accepted)
Carprofen (Rimadyl, Pfizer)	— 1 mg/kg SC ⁴⁰³ 1–2 mg/kg PO, IM, IV q12–24h ^{107,270,415} 2–4 mg/kg PO q8–12h ⁴⁶² 2–10 mg/kg SC, IM ^{106,546} 5–10 mg/kg PO, IM ^{293,345} 40 mg/kg body weight provided in feed ¹²³	High doses sometimes needed for PO route ⁴⁶² Chickens; pain threshold raised for at least 90 min postinjection Most species, including raptors Most species/analgesia Psittacines, passerines, raptors Raptors, Anseriformes, pigeons/postoperative analgesia Chickens/analgesia; dosage required to reach 8.3 µg/ml which is similar to therapeutic plasma levels in mammals (low plasma levels 0.28 µg/ml provided some analgesia for birds)
Celecoxib (Celebrex, Pfizer)	10 mg/kg PO q24h × 6–24 wk ¹²¹	Psittacines/clinical proventricular dilatation disease; clinical improvement may be seen within 7–14 days
Copper indomethacin (Avi-gesic, Vetapharm)	0.4 mg/kg IM ⁵⁴⁶	Most species/analgesic; antiinflammatory
Diclophenac (Voltarol, Geigy)	— 12.5 mg PO once ⁵⁴⁶	Analgesic, antiinflammatory; not available in the United States Pigeons/arthritis
Dimethylsulfoxide (DMSO) (90%) (Domoso, Fort Dodge)	1 ml/kg topical to affected area q4–7d ⁵¹⁹	Most species/antiinflammatory, analgesic; systemic absorption; use gloves during application
Dipyrrone (Novin, Vedco)	20–25 mg/kg SC, IM, IV q8–12h ^{535,612}	Ratites/analgesic for intestinal disorders; antipyretic

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Flunixin meglumine (Banamine, Schering)	—	Potential nephrotoxicity ^{247,462} ; hydration is essential; use only for short duration (maximum of 5 days) ^{107,462} ; 5 mg/kg led to renal ischemia and necrosis in Siberian cranes ⁴⁶² ; 5.5 mg/kg IM q24h × 7 days resulted in tubular necrosis in budgerigars ⁴⁶⁵ ; histologic evidence of renal damage was demonstrated in bobwhite quail given doses as low as 0.1 mg/kg (severity of lesions was directly correlated to dose) ³²¹	
	—	IM administration caused muscle necrosis in mallard ducks ³⁸² ; regurgitation may occur after administration ³⁰³	
	0.2 mg/kg IM ⁶¹²	Ratites	
	0.5 mg/kg IM ²⁵⁰	Most species, including psittacines	
	1–10 mg/kg IM, IV q24h ^{245,270,285,462,636}	Most species, including raptors, psittacines ⁵⁰⁸	
	1.1 mg/kg IM q12h ^{1,3}	Ostriches/myositis ³ ; 1.1 mg/kg IV to young ostriches eliminated from plasma with a mean half-life of 0.17 hr ²⁸	
	1.5 mg/kg IM q24h × 3 days ⁷²	Ostriches	
Ibuprofen (Pediaprofen, McNeil)	5–10 mg/kg PO q8–12h ⁴⁶²	Use pediatric suspension for small birds	
Ketoprofen (Ketofen, Fort Dodge)	1 mg/kg IM q24h × 1–10 days ^{44,546}	Raptors, waterfowl	221
	1–5 mg/kg IM q12h ⁵⁰⁵	Raptors	
	2 mg/kg PO, SC, IM ^{106,216,217,388,462}	Most species, including Japanese quail (PD), psittacines, passerines, raptors analgesia; absorbed quickly after PO or IM administration ^{216,217}	222
	5 mg/kg PO ³⁸²	Mallard ducks/PD	
	5–10 mg/kg IM ⁸³	Waterfowl	
Meclofenamic acid (Meclomen, Park-Davis)	2.2 mg/kg PO q24h ⁴¹⁵	Most species/analgesic; antiinflammatory	
Meloxicam (Metacam, Boehringer Ingelheim)	—	Analgesic, antiinflammatory only PO form available in the United States; half-life of meloxicam in chickens and pigeons was 3× longer compared with other bird species ^{26,27}	
	0.1–0.2 mg/kg PO, IM q24h ^{107,462,578}	Psittacines, raptors	
	0.5 mg/kg PO q12h	Psittacines/clinical proventricular dilatation disease ^c	
	0.5–1.0 mg/kg PO q12h ⁶⁴⁴	Ring-necked parakeets/PD	
Phenylbutazone Butaject, Vetus)	3.5–7.0 mg/kg PO q8–12h ⁵¹⁸	Psittacines	
	10–14 mg/kg PO q12h ⁶¹²	Ratites	
	20 mg/kg PO q8h ⁵¹⁸	Raptors	
Piroxicam (Feldene, Pfizer)	—	Indicated for chronic osteoarthritis; has been used to treat pain associated with chronic degenerative joint disease in cranes and other species	
	0.5 mg/kg PO q12h ⁴⁶²	Most species	
<p>a Unless otherwise noted, drugs provide analgesic, antipyretic, and antiinflammatory effects.</p> <p>b Nonsteroidal antiinflammatory agents may potentially cause gastrointestinal upset and hemorrhage as well as adverse renal effects ranging from fluid retention to renal failure.</p> <p>c Rosenthal K. Personal communication. 2004.</p>			

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TABLE 26 Nebulization agents used in birds.^a

Agent	Dosage	Species/Comments
N-acetyl-L-cysteine 10%-20% (Mucomyst, Bristol)	— 22 mg/ml sterile water until dissipated ⁵³⁸	See amikacin, aminophylline, gentamicin, for combinations Most species/mucolytic agent; tracheal irritation and reflex bronchoconstriction reported in mammals; use is preceded by bronchodilators in mammals ⁵⁵
Amikacin (Amiglyde, Aveco; Amikin, Bristol Labs)	5–6 mg/ml sterile water or saline × 15 min q8–12h ⁹¹ 6 mg/ml sterile water and 1 ml acetylcysteine (20%) until dissipated q8h ⁵³⁸	Most species/discontinue if polyuria develops Most species
Aminophylline (Roxane)	3 mg/ml sterile water or saline × 15 min ⁵³⁸	Most species/bronchodilator; allergic pulmonary disease; can mix with dexamethasone, aminoglycosides, and acetylcysteine
Amphotericin B (Fungizone, Squibb)	0.1–1.0 mg/ml sterile water × 15 min ²⁷⁰ 0.25 mg/ml saline × 15 min q12h ²⁴⁴ 1 mg/ml sterile water or saline × 15 min q12h ⁹⁵ 7–10 mg/ml saline ^{91,541}	Raptors/antifungal Hummingbirds/low efficacy; may cause weight loss Most species/antifungal Most species
Carbenicillin (Geocillin, Roerig)	20 mg/ml saline × 15 min q12h ⁵⁴²	Psittacines/ <i>Pseudomonas</i> pneumonia; use in combination with parenteral aminoglycosides
Cefotaxime (Claforan, Hoechst Roussel)	10 mg/ml saline × 10–30 min q6–12h ⁵⁴²	Most species
Ceftriaxone (Rocephin, Roche)	40 mg/ml sterile water ^{91,308} 40 mg/ml sterile water and DMSO ³⁰⁸ 200 mg/ml sterile water and DMSO ³⁰⁸	Poultry/PD Poultry/PD; 1 ceftriaxone in 10 ml sterile water, plus 15 ml DMSO Poultry/PD; 4 g ceftriaxone in 10 ml sterile water, plus 10 ml DMSO
Chloramphenicol, (Chloramphenicol, Fort Dodge, Parke-Davis)	13 mg/ml saline ⁹¹	Most species/human health concerns
Clotrimazole (1%) (Lotrimin, Schering)	10 mg/ml propylene glycol or polyethylene glycol × 30–45 min q24h × 3 days, off 2 days, repeat prn for up to 4 mo ^{8,91,304,611} 10 mg/ml polyethylene glycol (PEG 300) × 30–60 min ^{8,91,304}	Treatment of aspergillosis for stable patients without respiratory distress; can be toxic to psittacines at this dose Raptors, psittacines/used in combination with systemic amphotericin B, flucytosine, and itraconazole
Doxycycline hyclate (Vibramycin injection, Pfizer)	13 mg/ml saline ¹⁹²	Psittacines
Enilconazole (Imaverol, Janssen; Clinafarm, Sterwin)	10 mg/ml sterile water ^{45,91} 11 mg/ml saline ⁵⁴⁶ 0.2 mg/5 ml saline q12h × 21 days ³⁵⁴	Most species/antifungal Falcons/aspergillosis Most species, including raptors, psittacines
Enrofloxacin (Baytril, Bayer)	10 mg/ml saline ^{91,192}	Most species
Erythromycin (Erythro, Sanofi)	5–20 mg/ml saline × 15 min q8h ^{91,95,542}	Most species

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Gentamicin (Garamycin, Schering)	5 mg/ml saline × 15 min q8h ⁵⁴² 3–6 mg/ml saline or sterile water and 1–2 ml acetylcysteine (20%) × 20 min q8h ^{78,538}	Most species Most species, including cranes	
Lincomycin (Lincocin, Upjohn)	250 mg/ml water ⁹¹ 250 mg aerosolized drug/m ³ chamber × 15–30 min ⁸⁴	Most species Chickens/PD; antibiotic; therapeutic concentrations in blood, lungs, and trachea for up to 24 hr	
Miconazole (Daktarin, Janssen)	Nebulize 15 min q8h × 10 days ⁵⁴⁶	Raptors/aspergillosis	
Oxytetracycline (Liquamycin, Terramycin, Pfizer)	2 mg/ml × 60 min q4–6h ¹⁵²	Parakeets/PD	
Piperacillin (Piperacil, Lederle)	10 mg/ml saline × 10–30 min q6–12h ⁵⁴²	Most species	
Polymyxin B sulfate (Roerig)	66,000 IU/ml saline ¹⁹²	Psittacines/poorly absorbed from respiratory epithelium	
Sodium chloride	—	Viscosity of respiratory secretions may be decreased by hydration ⁵⁵	224
Spectinomycin (Spectam, Ceva)	13 mg/ml saline ^{91,192}	Most species	225
Sterile water	—	Viscosity of respiratory secretions may be decreased by hydration ⁵⁵	
Sulfadimethoxine (Albon, SmithKline)	13 mg/ml saline ^{91,192}	Most species	
Terbinafine (Lamisil, Novartis)	500 mg added to 1 ml acetylcysteine and 500 ml distilled water ¹²²	Psittacines/aspergillosis	
Terbutaline (Brethine, Novartis)	0.01 mg/kg with 9 ml saline ³⁵¹	Psittacines	
Tylosin (Tylan, Elanco)	10 mg/ml saline × 10–60 min q12h ^{192,542} 20 mg/ml DMSO or distilled water × 1 hr ^{362,363} 20 mg/ml DMSO and 0.5 ml saline ¹⁰⁶	Most species Pigeons, quail (PD), most species Psittacines	
<p>a Nebulization is an adjunctive therapy indicated for rhinitis, sinusitis, tracheitis, pneumonia, airsacculitis, and syringeal aspergilloma. Optimal particle size for deposition in the trachea is 2–10 µm. Optimal particle size for peripheral airways is 0.5–5.0 µm. Treatments of 30–45 min repeated every 4–12 hr are recommended. Caution: do not overhydrate airways and flood the respiratory tract.⁵⁵</p>			225

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TABLE 27 Agents used in the treatment of toxicologic conditions of birds.

Agent	Dosage	Species/Comments
Atropine sulfate (Atropine Sulfate, Abbott)	— 0.01–0.02 mg/kg SC, IM ⁵⁵ 0.03–0.05 mg/kg SC, IM, IV q8h ⁶¹² 0.04–0.1 mg/kg IM ⁵⁵ 0.05 mg/kg SC, IM q1h ⁵⁴⁶ 0.1 mg/kg IM, IV q3–4h ^{83,546} 0.2–0.5 mg/kg IM, IV q3–4h ^{335,538}	Antidote for organophosphate (acetylcholinesterase inhibitor) toxicity Most species/facilitates bronchodilation in acutely dyspneic animals; treatment of choice for anticholinesterase-induced respiratory distress Ratites Psittacines/bronchodilation in acutely dyspneic animals; treatment of choice for anticholinesterase-induced respiratory distress Psittacines Waterfowl, raptors Most species, including pigeons, raptors/organophosphate toxicity
Bismuth sulfate (Bismusal, Bimeda)	1–2 ml/kg PO ^{335,546}	Most species/weak adsorbent, demulcent; may be useful for toxin removal
Botulinum type C antitoxin (100 IU/ml) (National Wildlife Health Center, Madison, Wis; 608–270–2400)	IP ^{394,649}	Not commercially available; produced for experimental use in migratory waterfowl ⁴⁵⁵
Calcium EDTA (edetate calcium disodium) (Calcium Disodium Versenate, 3M Pharmaceuticals)	— 10–40 mg/kg IM q12h × 5–10 days ³¹⁹ 20–70 mg/kg IV ¹²⁶ 25–50 mg/kg IV q12h ⁴²⁵	Preferred initial chelator for lead and zinc toxicity; may cause renal tubular necrosis in mammals; maintain hydration and monitor patient for PU/PD; orally administered calcium EDTA may increase the amount of lead absorbed from the gastrointestinal tract ⁴⁷³ Raptors Most species/empirical diagnosis; signs should resolve for up to 48 hr; diluted at 1:4 in saline Geese
	30–35 mg/kg IM q12h × 3–5 days, off 3–4 days, repeat prn ³³⁵ 35 mg/kg IM, IV q8h × 3–4 days, off 2 days, repeat prn ³⁰² 35 mg/kg PO q12h ⁴⁰² 40 mg/kg IM q12h ¹³³ 50 mg/kg IM q12h × up to 23 days ⁵⁵⁰	Most species Most species/may be given PO after initial therapy until all lead fragments are dissolved or passed (see earlier comments) Cockatiels/PD; reduces lead levels when use alone or with DMSA Raptors/no deleterious effects observed
Charcoal, activated (Toxiban, Vet-A-Mix)	— 52 mg/kg PO once ⁴¹² 2000–8000 mg/kg PO ^{45,126,396,518,546}	Adsorbs toxins from the intestinal tract; may be mixed with hemicellulose to act as a bulk laxative to aid in the passage of ingested toxins; administration before cathartic use may help bind small particles of heavy metal ¹²⁶ ; see magnesium hydroxide (Table 36) for combination A component of oiled bird treatment; alternatively, may use bismuth Most species

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Deferiprone (Ferriprox, Apotex, Inc., Ontario, Canada)	50 mg/kg PO q12h × 30 days ^{115,116,303,639}	Toucans, pigeons, chickens/iron chelation; may produce rust-colored urates; supplemental zinc may be indicated ¹¹⁶ ; an orphan drug in the United States	
Deferoxamine mesylate (Desferal, Ciba-Geigy)	— 20 mg/kg PO initially, then IM q4h until recovery ³³⁵ 20 mg/kg PO q4h until recovery ³³⁵ 40 mg/kg IM q24h × 7 days ⁴⁴³	Preferred iron chelator for hemochromatosis; may take 3 mo to see response; may cause reddish discoloration of urine ⁶¹¹ ; avoid in birds with renal disease ⁶¹¹ ; combine with a low-iron diet ¹¹⁶ Most species Most species Mynahs	227
	100 mg/kg PO, SC, IM q24h up to 3.5 mo ^{110,115,415,611}	Most species, including toucans	228
Diethylene triamine pentaacetic acid (DTPA)	30 mg/kg IM q12h ⁶¹³	Lead toxicity	
Dimercaprol (BAL in Oil, Becton Dickinson)	2.5–5.0 mg/kg IM q4h × 2 days, then q12h × 10 days or until recovery ⁶¹¹ 25–35 mg/kg PO q12h × 3–5 wk ⁵¹⁹	Heavy metal toxicity; arsenic, gold, mercury (if ingestion <2 hr) ¹⁹⁸ ; rarely used Give 5 days per week	
Dimercaptosuccinic acid (DMSA or succimer) (DMSA, Aldrich; Chemet, Bock Pharmacol)	— 25–35 mg/kg PO q12h × 5 day/wk × 3–5 wk ^{303,335} 25–35 mg/kg PO q24h × 10 days ^{106,335} 30 mg/kg PO q12h ≥7 days ²⁶⁶ 40 mg/kg PO q12h × 21 days ¹³³	Preferred oral chelator for lead toxicity; effective for zinc toxicity ⁶²⁴ ; may be effective for mercury toxicity ³⁰³ ; can use with calcium EDTA ¹³³ Most species, including raptors ³⁰³ /lead toxicity Psittacines, raptors/lead and zinc toxicity Most species/lead toxicity Cockatiels/PD; lead toxicity; reduces lead levels when used alone or in combination with calcium EDTA; 80 mg/kg resulted in death in >60% of cockatiels	
Magnesium hydroxide (M)/activated charcoal (C) (Milk of Magnesia, Roxane)	(M) 10–12 ml + (C) 1 tsp powder ³³⁵	Most species/cathartic; adsorbent	
Magnesium sulfate (Epsom salts)	500–1000 mg/kg PO q12–24h × 1–3 days ^{44,270,335,546}	Raptors, waterfowl/cathartic used in lead toxicity ^a ; give 30 min after activated charcoal treatment or can cause lethargy ³³⁵	
Penicillamine (Cuprimine, Merck)	— 30 mg/kg PO q12h × 7 days minimum ²⁶⁶	Lead, zinc toxicity; preferred chelator for copper toxicity; may be used for mercury toxicity ⁵¹⁹ Most species/initially supplemented with calcium EDTA once in severe neurologic disease	228
	30–55 mg/kg PO q12h × 7–14 days ^{44,303,319,335} 50–55 mg/kg PO q24h × 1–6 wk ^{106,126}	Most species, including raptors, waterfowl Most species, including psittacines, raptors/use in combination with calcium EDTA for several days followed by penicillamine × 3–6 wk ¹²⁶	229
Phytonadione (see vitamin K)	—	See vitamin K	
Pralidoxime (2-PAM) (Protopam, Wyeth-Ayerst)	— 10–100 mg/kg IM q24–48h or repeat once in 6 hr ^{44,335,546}	Administer within 24–36 hr of organophosphate intoxication ⁶¹¹ ; use lower dose in combination with atropine Psittacines, raptors, waterfowl	

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Sodium sulfate (Glauber's salt) (GoLyteLy, Braintree; anhydrous sodium sulfate, ACS Grade, Fisher Scientific)	— 500 mg/kg PO q48h ¹³³ 500–2000 mg/kg PO ⁵¹⁸ 2000 mg/kg PO q24h × 2 days ^{396,518}	Cathartic ^a ; contraindicated with impaired gastrointestinal function; maintain hydration ⁶¹¹ Cockatiels/PD; did not result in further decreases in lead concentrations when given to birds receiving calcium EDTA alone or in combination with DMSA Most species Most species
Succimer (Chemet, Bock Pharmacal)	—	See dimercaptosuccinic acid
Tea (black tea leaves) (Ceylon CO ₂ -decaffeinated tea leaves, Frontier Natural Products Co-op)	8 g/kg diet ⁵⁶⁰	Starlings/hepatic iron concentrations did not increase significantly in starlings on an iron-enriched diet with tea leaves supplementation; tea containing approximately 20% (by weight) condensed tannins were blended directly into the food mixture (8 g/kg diet)
Vitamin K ₁ (Veda-K ₁ , Vedco)	0.2–2.2 mg/kg IM q4–8h until stable, then q24h PO, IM × 14–28 days ^{303,335}	Most species, including raptors/rodenticide toxicity

a Cathartics increase gastrointestinal motility and are used to evacuate the gut and prevent absorption of toxins.

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TABLE 28 Psychotropic agents used in birds.^a

Agent	Dosage	Species/Comments
Amitriptyline (Elavil, Stuart)	— 1–5 mg/kg PO q12–24h ⁵⁴⁶ 2 mg/kg PO q24h ¹⁶¹	Tricyclic antidepressant; inhibits serotonin reuptake; antihistamine Most species/allergic feather picking; obsessive-compulsive disorders; phobias ⁶³² Psittacines/minimum of 30 days
Buspirone HCl (Buspar, Bristol-Myers Squibb)	0.5 mg/kg PO q12h ³⁰⁷	Anxiolytic; used to control behavior interpreted as paradoxical anxiety caused by clomipramine
Carbamazepine (Tegretol, Basel)	3–10 mg/kg PO q24h ⁴⁹⁷ 166 mg/L drinking water ⁵³⁸	Most species/anticonvulsant, analgesic; may cause bone marrow suppression (including aplastic anemia and agranulocytosis) and hepatotoxicity; combination with chlorpromazine or haloperidol recommended for initial treatment during the first 2 wk ⁵³⁸
Chlorpromazine (Thorazine, SmithKline Beecham)	— Mix 1 ml stock solution/120 ml drinking water or 0.2–1.0 ml/kg stock PO q12–24h prn ⁵³⁸ 0.1–0.2 mg/kg IM once ⁵³⁸	Phenothiazine; dopamine antagonist ⁶³² used in some cases of feather picking; correct underlying problems and discontinue within 30 days ⁶³² ; efficacy diminishes in 14–30 days when given PO ⁵³⁸ ; may cause ataxia, regurgitation, drowsiness ⁵⁴² Stock solution: crush five 25 mg tablets and mix with 31 ml simple syrup; start at low dose initially; mild sedation Cockatoos, ringneck parakeets/use with carbamazepine after removal of Elizabethan collar; mild sedation and decreases obsessive behaviors
Clomipramine (Anafranil, Basel; Clomicalm, Novartis)	—	Tricyclic antidepressant; antihistamine; may cause regurgitation, drowsiness; adverse effects in mammals include cardiac conduction abnormalities, tachyarrhythmias, postural hypotension, dry mucous membranes, urinary retention, constipation, and lowering of the seizure threshold ³⁰⁷ ; anecdotal reports of death in birds possibly associated with preexisting arrhythmias ²¹¹ ; wait 2–3 wk before adjusting dose ⁵⁶
	0.5–1.0 mg/kg PO q12–24h ^{211,610,611} 1 mg/kg PO q24h or divided q12h × 6 wk ⁴⁹⁹ 1–2 mg/kg PO q24h ²⁸⁷ 3 mg/kg PO q12h × 6 wk ^{561,647} 4.0–9.5 mg/kg PO q12h ³⁰⁷	Psittacines/feather picking; self-mutilation; start with low dose and gradually increase over 4–5 days Psittacines/allergic feather picking; obsessive-compulsive disorders; phobias ⁶³² ; occasional regurgitation and drowsiness observed; 2 of 11 birds decreased feather picking Psittacines/begin with 1 mg/kg and increase if needed Cockatoos/no appreciable deleterious side effects; no significant differences between baseline and posttreatment bloodwork or body weight ⁶⁴⁷ African grey parrots/behavior interpreted as paradoxical anxiety; combine with anxiolytic therapy (buspirone)

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Delmadinone (Tardak, Syntex)	1 mg/kg IM once ³⁴⁴	Psittacines/sexual behavior problems; not available in the United States	
Diazepam (Valium, Roche)	— 0.25–0.50 mg/kg IM, IV q24h × 2–3 days ⁵⁸⁹ 0.5 mg/kg PO ³⁹⁸ 0.5–0.6 mg/kg IM ^{34,211} 0.5–1.0 mg/kg IM, IV q8–12h ^{396,542} 0.5–1.5 mg/kg PO, IM, IV q8h ¹⁰⁶ 2.5–4.0 mg/kg PO q6–8h ⁴⁵ 10–20 mg/L drinking water ²¹⁴	Benzodiazepine sedative; anxiolytic; stress-associated feather picking ⁶³² ; useful as sole agent or in combination with phenobarbital for seizure control Raptors/appetite stimulant Passerines/calms fractious species while improving acceptance to a novel captive diet; oral solution (1 mg/ml; Roxane Laboratories) worked best Most species/facilitates acceptance of Elizabethan collar, especially in lovebirds Most species/control of seizures Psittacines/control of seizures Psittacines/sedation Most species	231
Diphenhydramine (Benadryl, Parke-Davis; Hyrexin-50, Hyrex)	— 2–4 mg/kg PO q12h ²¹⁴ 2 mg/L drinking water ⁶³²	Antihistamine; mild hypnotic effects; allergic feather picking Most species Most species	232
Doxepin (Sinequan, Roerig)	— 0.5–1.0 mg/kg PO q12h ^{214,293}	Tricyclic antidepressant; antihistamine; dose may be increased at 14-day intervals ¹⁰⁶ ; may cause sedation ⁶³² Most species/allergic feather picking	
Fluoxetine (Prozac, Dista)	— 0.4 mg/kg PO q24h ⁴⁵ 2–3 mg/kg PO q12–24h ^{407,531}	Selective serotonin reuptake inhibitor; antidepressant; adjunctive treatment for depression-induced feather picking ⁶³² Psittacines/feather picking Most species, including psittacines	
Haloperidol (Haldol, McNeil)	— 0.1 mg/kg PO q12–24h ²⁸⁸ 0.1–0.4 mg/kg PO q24h ^{45,287,344} 0.10–0.15 mg/kg PO q12–24h ^{211,349,542} 0.2 mg/kg PO q12h ⁵⁴² 1–2 mg/kg IM q14–21d ^{214,611} 6.4 mg/L drinking water × 7 mo ²⁷³	Butyrophenone dopamine antagonist tranquilizer; may work best with self-mutilators ^{273,349} ; may cause anorexia or depression ⁶³² ; reports of illness, extrapyramidal signs and death reported in macaws ^{287,346} Macaws/aggression; feather picking; used in conjunction with lorazepam Psittacines/dose may be increased in increments of 0.01 mg/kg if no response is seen in 5–7 days and no adverse effects are observed Birds weighing >1 kg Most species <1 kg Most species, including psittacines African grey parrots/feather picking	
Hydroxyzine (Atarax, Roerig)	— 2.0–2.2 mg/kg PO q8h ^{214,334} 30–40 mg/L drinking water ^{56,214}	Antihistamine with mild sedative effects Most species/allergic feather picking Most species	232
Lorazepam (Ativan, Wyeth-Ayerst)	— 0.1 mg/kg PO q12h ²⁸⁸	Benzodiazepine with anxiolytic and sedative effects Macaws/aggression; feather picking; use alone or with haloperidol	233

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Megestrol acetate (Ovaban, Schering)	—	Progestin providing nonspecific calming effects ⁵⁶ ; side effects can be severe (diabetic-like); seldom used
	2.5 mg/kg PO q24h × 7 days then 1–2×/wk ^{45,344}	Psittacines/feather picking; sexual behavior problems
	10–20 mg/L drinking water × 7–10 days, then 1–2×/wk ²⁰³	Most species/feather picking
Mibolerone (Cheque Drops, Upjohn)	85 µg/L drinking water ¹²⁰	Psittacines/anabolic, androgenic steroid; feather picking
Naloxone HCl (Narcan, DuPont)	2 mg/kg IV ²⁸⁷	Psittacines/opioid antagonist; may be used to determine the response of stereotypic behavior to antagonist therapy; reduction of the behavior should be observed within 20 min
Naltrexone HCl (Trexonil, Wildlife Pharmaceuticals; ReVia, Dupont)	1.5 mg/kg PO q8–12h × 1–18 mo ⁶¹⁵	Most species/opioid antagonist; feather picking; self-mutilation; contraindicated in patients with liver disease; may need to increase dosage 2–6× to be effective; dissolve tablet in 10 ml sterile water; preservative does not go into solution
Nortriptyline (Pamelor, Sandoz)	16 mg/L drinking water (2 mg/120 ml) ²¹⁴	Most species/tricyclic antidepressant; feather picking; seldom used; decrease dose or discontinue if hyperactivity develops; taper dose to discontinue ⁶¹¹
Paroxetine (Paxil, SmithKline Beecham)	1–2 mg/kg q24h ³¹⁴	Macaw, ibis/selective serotonin reuptake inhibitor; feather picking; self-mutilation; generally requires long-term therapy
	3 mg/kg PO q24h ³¹⁴	Pigeons
Phenobarbital sodium (Wyeth-Ayerst)	—	Barbiturate anticonvulsant; mild sedative effect; long-term seizure management; adjust dosage based on blood levels; may cause deep sedation and inability to perch ⁵⁴⁶
	1–5 mg/kg IV bolus ²¹	Most species/status epilepticus; begin at low end of dosage range and increase for refractory seizures
	1–7 mg/kg PO q8–12h ²¹⁴	Most species/feather picking; mild sedative effect
	2–7 mg/kg PO q12h ^{40,211,297}	Most species, including Amazon parrots/seizures; self-mutilation
	50–80 mg/L drinking water ^{489,652}	Most species, including Amazon parrots/idiopathic epilepsy
Potassium bromide (Aldrich; Fisher Scientific)	—	Long-term seizure management; use as sole agent or in conjunction with phenobarbital; monitor blood levels, which may take up to 90 days to establish steady state ⁶⁵⁵ ; not approved in the United States; may be obtained from chemical companies or compounding pharmacies; FDA gives permission to purchase and buy the drug through its Division of Compliance (301–594–1785) ⁴⁸²
	25 mg/kg PO q24h ¹⁰⁵	Most species
	50–80 mg/kg PO q24h ⁶⁵⁵	Pigeons
	75 mg/kg PO ¹⁰⁶	Psittacines
	80 mg/kg PO q24h ⁵⁹	Umbrella cockatoos/serum drug levels ranged from 1.7–2.2 mg/ml

a The use of psychotropic agents in birds is controversial because safety, efficacy, and pharmacologic effects are poorly documented. Anxiolytics or tricyclic antidepressants may be useful for stereotypic

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behaviors or mutilation. Selective serotonin reuptake inhibitors may prove helpful for explosive behaviors.⁴⁵⁷ Consider metabolic scaling when calculating dosages. Treatment should always include behavioral and environmental modification.

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TABLE 29 Nutritional/mineral support used in birds.

Agent	Dosage	Species/Comments
Biotin (Vet-A-Min)	0.05 mg/kg PO q24h × 30–60 days ^{44,546}	Raptors/beak and nail regrowth
Brewers yeast	30 mg/bird in feed ⁴⁴	Pigeons/brittle plumage; use daily during molt
Calcium	—	Recommended dietary levels
	3–10 mg/kg feed (0.3%–1.0%) ²⁹⁵	Laying parrots ^a
	4–8 mg/kg feed (0.4%–0.8%) ⁴³⁶	Growing Muscovy ducks
	8 mg/kg feed (0.8%) ⁴³⁶	Growing Japanese quail
	8–10 mg/kg feed (0.8%–1.0%) ⁴³⁶	Growing chickens
	18.8–32.5 mg/kg feed (1.88%–3.25%) ⁴³⁶	Laying chickens/3.25% recommended for hens that lay eggs daily
	22.5 mg/kg feed (2.25%) ⁴³⁶	Laying turkeys
Calcium borogluconate (10%) (Calcibor, CBG20, Arnolds)	50–100 mg/kg IM, IV ⁴⁵	Psittacines/20% solution
	100–500 mg/kg SC, IV (slow) once ⁴⁴	Raptors/hypocalcemia
	300 mg/kg IV ¹⁹¹	Goshawks
Calcium chloride	150–200 mg/kg IM, IV (slow) q8h ⁶⁰⁵	Hypocalcemia; seldom used
Calcium glubionate (Calciquid, Breckenridge Pharmaceuticals; Calcionate Syrup, Watson/Rugby)	—	Most species/hypocalcemia
	23 mg/kg PO q24h ³⁰⁶	Psittacines (neonates)
	25 mg/kg PO ^{35,270}	Most species, including raptors
	150 mg/kg PO q12h ^{272,611}	Most species
	750 mg/L drinking water ²⁷²	Most species
Calcium gluconate (10%) (Calcium Gluconate, Lilly; Roxane; Fort Dodge)	—	Hypocalcemia; dilute 1:1 with saline or sterile water for IM or IV injections
	5–10 mg/kg IV slowly to effect ⁶¹¹	Hypocalcemic tetany
	5–10 mg/kg SC, IM q12h prn ^{546,611}	Psittacines
	10–100 mg/kg IM ²⁹⁵	Psittacines/acute presentation of hypocalcemia
	25–50 mg/kg SC, IV (slow) ⁵⁴⁶	Pigeons
	50–100 mg/kg IM (diluted), IV (slow) once ^{270,272,303,518,539,546}	Most species, including psittacines, pigeons, raptors
	100–500 mg/kg SC, IV (slow) once ⁵⁴⁶	Raptors/hypocalcemia
	1 ml/30 ml (3300 mg/L) drinking water ⁶¹¹	Calcium supplementation
Calcium lactate/calcium glycerophosphate (Calphosan, Glenwood)	5–10 mg/kg IM q7d prn ^{35,270,272,542}	Most species, including raptors/hypocalcemia
	50–100 mg/kg IV (slow bolus) once ⁴⁹⁴	African grey parrots
Calcium levulinate (Vedco)	75–100 mg/kg IM, IV ^{272,402}	Most species/hypocalcemia
L-Carnitine (Lonza Inc)	1000 mg/kg feed ¹³⁴	Budgerigars/PD; lipomas; average lipoma size decreased significantly
Dextrose (50%)	50–100 mg/kg IV (slow bolus) to effect ^{542,611}	Hypoglycemia; can dilute with fluids
	500–1000 mg/kg IV (slow bolus) ^{94,491}	Hypoglycemia; can dilute with fluids
Diatrizoate meglumine sodium (37% iodine) (Renografin-76, Solvay)	—	Parenteral treatment of goiter is generally reserved for emergency situations
	122 mg/kg IM ^{415,519}	Budgerigars/thyroid hyperplasia
Essential fatty acids (Dermplus Liquid, C-Vet)	0.5 ml/kg PO q24h × 50 days or indefinitely ⁵⁴⁶	Raptors/pruritic dermatitis (atopy)

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Fatty acids (omega-3, omega-6)	0.1–0.2 ml/kg of flaxseed oil to corn oil mixed at a ratio of 1:4 PO or added to food; ratio of omega-6/omega-3 is 4–5:1 ^{32,153} 0.11 ml/kg q24h in a 5:1 ratio of omega-6/omega-3 ¹³⁸	Psittacines, pigeons/renal disease; used to reduce thromboxane A ₂ synthesis in platelets and glomerular cells; adjunct therapy for arthritis, feather-picking, mutilators, and neoplasia; 2–4 wk of therapy are required to recognize effects; may increase dietary vitamin E requirements; consider supplementation with long-term use ^{32,153} Psittacines/glomerulonephritis, pancreatitis	
Folic acid (Folicet, Mission Pharmaceuticals)	50–100 µg IM ²³ 500 µg/100 g feed ⁶⁰⁸	Poultry (chicks)/treatment of deficiency; anemia improved in 4 days Poultry (chicks)/treatment of deficiency	236
Hemicellulose (Metamucil, Searle)	— Small amount on food daily ⁵³⁵ 0.5 tsp/60 ml hand feeding formula or baby food gruel ³³⁵ 1 Tbs/60 ml water q24h ⁶¹²	For bulk in diet; facilitates defecation in bowel deficit disorders and other conditions Most species Psittacines/bulk diet to delay absorption of an ingested toxin Ostriches (chicks)/impaction	237
Iodine (Lugol's iodine)	0.2 ml/L drinking water daily ²⁷² 2 parts iodine + 28 parts water; 3 drops into 100 ml drinking water ⁵⁴⁶	Most species/thyroid hyperplasia Budgerigars/thyroid hyperplasia	
Iodine (sodium iodide 20%)	— 2 mg (0.01 ml)/bird IM prn ³⁵ 60 mg (0.3 ml)/kg IM ²⁷²	Parenteral treatment of goiter is generally reserved for emergency situations or initial treatment of severe thyroid dysplasia; continue with oral therapy when improvement is noted Budgerigars Most species/thyroid hyperplasia	
Iron	20–40 mg/kg feed ^{115,116}	Toucans/levels recommended for a low-iron diet	
Iron dextran	10 mg/kg IM, repeat in 7–10 days prn ^{44,518}	Most species, including raptors, waterfowl/iron deficiency anemia; use cautiously in species in which iron storage disease is common (e.g., toucans, mynahs, starlings, birds of paradise, other passerines)	
Lactobacillus (Bene-Bac, Pet-Ag)	1 pinch/day/bird ⁶¹¹ 1 tsp/L hand-feeding formula ⁶¹¹	Stimulation of normal gastrointestinal flora regrowth Most species	
Niacin (nicotinic acid)	50 mg/kg PO q8h ⁴⁸⁹	Psittacines/yolk emboli; see gemfibrozil (Table 36)	237
Pancreatic enzyme powder (Viokase-V Powder, Fort Dodge)	— 2–5 g/kg ⁶¹¹ 1/8 tsp/kg feed ^{11,611} 1/8 tsp/60–120 g lightly oil-coated seed ⁵³⁸ 1/8 tsp/30–120 ml hand-feeding formula prn ⁴⁴⁵	Most species/pancreatic insufficiency; maldigestion; mix with food and let stand 30 min ⁶¹¹ Most species Most species Most species Psittacines (neonates)	238
Phytonadione	—	See vitamin K ₁	
Selenium (Seletoc, Schering)	0.05–0.10 mg Se/kg IM q14d ⁵¹⁸ 0.06 mg Se/kg IM q3–14d ²⁷²	Most species/neuromuscular diseases (capture myopathy, white muscle disease, some cardiomyopathies); may be useful in some cockatiels with jaw, eyelid, and tongue paralysis ⁵¹⁸	
Sodium chloride (buffered salt tablet)	450 mg PO daily ¹⁹⁶	Penguins/prevents atrophy of salt gland	

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Vitamin A (Aquasol A Parenteral, Astra)	200 IU/kg IM ³⁰⁰ 2000 IU/kg PO, IM ²⁵ 5000 IU/kg IM q24h × 14 days, then 250–1000 IU/kg q24h PO ¹⁰⁶ 20,000 IU/kg IM ⁶⁰⁵ 33,000 IU/kg (10,000 IU/300 g) IM q7d ²⁷² 50,000 IU/kg IM q7d ³⁰⁶ 1 ml/135 kg IM ²	Raptors (juveniles)/supplemental therapy for pox Psittacines/adjunctive therapy for pox Psittacines/adjunctive therapy for respiratory or epithelial disease Most species/hypovitaminosis A; maximum dose; improves skin healing Most species/hypovitaminosis A Psittacines (neonates) Ostriches/hypovitaminosis A	
Vitamin B ₁ (thiamine)	— 1–2 mg/kg PO q24h ⁵¹⁹ 1–2 mg/kg IM q24h ^{270,466,518} 1–3 mg/kg IM q7d ^{303,518} 1–50 mg/kg PO q24h × 7 days or indefinitely ⁵⁴⁶	Thiamine deficiency; requirements may be higher if thiaminase is present in diet ^b Raptors, penguins, cranes/daily supplement Vultures, raptors, cranes, penguins/CNS signs Most species, including raptors Raptors	238
	1–2 mg/kg feed ⁴⁶⁶ 2 mg/kg IM ⁶¹² 3–30 mg/kg IM q7d ²⁷⁰ 30 mg/kg feed (as fed basis) q48h ²⁷⁰ 25–30 mg/kg fish (wet basis) ⁴² 2850 mg/L drinking water q7d ⁵⁴⁶	Vultures Ratites/curly toe paralysis Raptors/stimulates appetite, hematopoiesis; neuromuscular disease; liver disease; supportive therapy; adjunct to sulfa therapy Raptors/supplement for piscivorous species fed frozen fish Piscivorous species/recommended level of supplementation Pigeons	239
Vitamin B ₁₂ (cyanocobalamin)	0.25–0.5 mg/kg IM q7d ^{270,518,546} 2–5 mg/bird SC ⁶⁰⁸	Most species, including psittacines, raptors/anemia; may cause pink droppings ⁵⁴⁶ Pigeons/vitamin B ₁₂ deficiency	
Vitamin B complex	—	Usually dosed based on thiamine (see vitamin B ₁)	
Vitamin C (ascorbic acid)	20–50 mg/kg IM q1–7d ^{300,302,519}	Most species, including raptors/nutritional support; supplemental therapy for pox	
Vitamin D ₃ (Vital E-A + D, Schering Plough)	3,300 IU/kg (1000 IU/300 g) IM q7d prn ²⁷² 6600 IU/kg IM once ⁶⁵² 11–30 min of direct sunlight/day ²⁹⁵	Most species/hypovitaminosis D ₃ ; hypervitaminosis D may occur with excessive use Most species Chickens/sufficient for endogenous synthesis of vitamin D	
Vitamin E (Vitamin E20, Horse Health Products; Bo-SE, Schering Plough)	— 0.06 mg/kg IM q7d ⁵⁴⁶ 0.06 mg/kg IM ⁶¹² 15 mg/kg PO once ³⁸⁶ 70 mg/kg IM q24h for up to 5 days ⁶⁶² 200–300 mg/kg IM ³⁹⁶ 200–400 mg/day PO ¹¹ 73.5 mg/kg fish (wet basis) ⁶⁶²	1 mg d α-tocopherol acetate = 1.36 IU; 1 mg dl α-tocopherol acetate = 1 IU; injectable vitamin E has lower efficacy ³⁸⁶ Psittacines/vitamin E deficiency Ratites/prevention or treatment of capture myopathy Raptors/PD; administer without food Pelicans/vitamin E deficiency; steatitis Ostriches (chicks) Great blue herons Pelicans/supplementation	239

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	100 mg/kg fish (wet basis) ^{42,662}	Piscivorous species/recommended level of supplementation
	4400–8800 mg/kg feed ¹¹	Ostriches (chicks)/hypovitaminosis E
Vitamin E/γ-linolenic acid (2%), linoleic acid (71%) (Derm Caps, DVM Pharmaceuticals)	0.1 ml/kg PO q24h ^{293,415,519}	Most species/feather picking; use liquid from gel caps
	4000 mg linolenic acid/kg feed ⁴²⁴	Japanese quail/PD; reduces essential fatty acid–deficient hepatic lipidosis
Vitamin K ₁ (phytonadione)	0.025–2.5 mg/kg IM q12h ^{222,652}	Most species
	0.2–2.2 mg/kg IM q4–8h until stable, then q24h × 14 days ^{303,335}	Most species, including raptors/rodenticide toxicity
	2.5 mg/kg IM q24h until hemostasis, then q7d prn ⁵³⁸	Vitamin K–responsive disorders (conures); hematochezia (Amazon parrots); coagulopathies (psittacines)
	5 mg/kg IM q24h for several days ^{49,612}	Ratites/coagulopathy
	10–12.5 mg/kg SC q12h × 4 days ⁶⁶²	Pelicans/coagulopathy
	10–20 mg/kg IM q12–24h ¹¹	Psittacines
	0.1 mg/kg feed ²⁹²	Turkeys/PD; as effective as 1–2 mg/kg in reducing plasma prothrombin time
	5 mg/kg feed ⁵³⁸	Budgerigars/vitamin K–responsive bleeding disorders; mix contents of gel cap into small grain seed mix and coat seed lightly

- a Grains and seeds commonly fed to parrots contain calcium levels of approximately 0.02%–0.1% DM.
- b Food items known to contain appreciable amounts of thiaminase include clams, herring, smelt, and mackerel.⁴²

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TABLE 30 Ophthalmologic agents used in birds.^a

Agent	Dosage	Species/Comments
Amphotericin B (Fungizone, Squibb)	125 µg/5 ml sterile water subconjunctival ⁷	Ducks (ornamental)/candidiasis of third eyelid
Amphotericin B ointment (4%) (formulated)	Topical q24h ⁷	Ducks (ornamental)/candidiasis of third eyelid; administered in conjunction with systemic antifungal therapy
Atropine (0.4%–0.5%) (Atrophate, Schering-Plough)	0.6 mg/bird topical ⁴⁹⁵ Topical ⁶⁴	Cockatoos/PD; partial mydriasis; some birds have iridal smooth muscle; may cause ocular irritation, weakness, shallow breathing; dilute with 0.9% saline ^a Ratites/partial mydriasis; use in combination with curariform drugs; some ratites have iridal smooth muscle ^a
Bacitracin/neomycin/polymyxin B sulfate (Neobacimyx, Schering-Plough)	Small bead topical ⁵³⁸	Most species/antibiotic; corneal ulcers, conjunctivitis; excessive amounts will cause eye-wiping and soiled plumage
Chloramphenicol ophthalmic drops (Chloromycetin ophthalmic solution, Monarch)	1 drop topical q6–8h ²⁹³	Pigeons/antibiotic
Ciprofloxacin HCl (0.3%) (Ciloxan ophthalmic ointment or solution, Alcon)	1 drop topical q4–8h ⁷	Most species/antibiotic; corneal ulcers, conjunctivitis (e.g., <i>Chlamydophila</i> , <i>Mycoplasma</i>)
Demercurium bromide (0.125%) (Humorsol ophthalmic solution, Merck)	1 drop topical ⁷	Topical anesthetic; allows removal of <i>Thelazia</i>
Dexamethasone (0.1%) ophthalmic drops (Merck)	1 drop topical q4–8h ²⁷⁰	Raptors/traumatic anterior uveitis without corneal ulceration
Fumagillin (Clemastine fumarate, Schein)	1 drop topical q2h ⁷⁶	Amazon parrot/fungal and microsporidial keratoconjunctivitis
Gentamicin sulfate (Gentocin, Schering-Plough)	1 drop topical q4–8h ⁵³⁸	Most species/antibiotic; corneal ulcers; causes irritation
Isoflurane (Aerrane, Anaquest)	1%–2% maintenance ⁴⁷⁶	Most species/mydriasis ^a
Ivermectin (Ivomec, Merial)	0.005–0.05 mg topical q24h × 10 days ⁶⁰⁶	Chicken/PD; conjunctival oxyspirurid (nematode) infection; no adverse effects were seen with topical use
Ketamine (Ketaset, Fort Dodge)	15–20 mg/kg IM ¹²⁴	Raptors/mydriasis; will cause sedation; isoflurane anesthesia is more commonly used ^a
Miconazole (Monistat IV, Janssen)	1 drop topical q2h ⁷⁶	Fungal keratitis
Miconazole vaginal cream (2%) (Monistat, Ortho-McNeal)	Topical ⁷	Antifungal
Natamycin (Natacyn, Alcon)	1 drop topical q6h ⁵¹⁸	Antifungal; gradually taper off
Neomycin/polymyxin B/gramicidin (Bausch & Lomb)	1 drop topical q2–8h ⁵³⁸	Most species/antibiotic; corneal ulcers; conjunctivitis
Oxybuprocaine (0.45%) (Benoxinat SE Thilo, Alcon)	Topical ³³⁰	Pigeons, bustards/topical anesthetic of choice because of reliable effect with minimal side effects
Oxytetracycline/polymyxin B (Terramycin, Pfizer)	Small bead topical ⁵³⁸	Most species/antibiotic; conjunctivitis; excessive amounts will cause eye-wiping and soiled plumage
Phenylephrine (2.5%) (AK Dilate, Akorn)	Topical ⁶⁴	Ratites/partial mydriasis; use in combination with curariform drugs; some ratites have iridal smooth muscle ^a

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Phenylephrine (4%–5%)	—	4%–5% ophthalmic solution is not available in the United States	
	6 mg/bird topical ⁴⁹⁵	Cockatoos/PD; partial mydriasis; some birds have iridal smooth muscle; may cause ocular irritation, weakness, shallow breathing; dilute with 0.9% saline	
Pimaricin (Natacyn, Alcon)	1 drop topical q6h, taper after 14–21 days ⁵¹⁹	Most species/polyene antifungal	242
Prednisolone acetate (1%) (Econopred, Alcon)	1 drop q4–8h ²⁷⁰	Raptors/traumatic anterior uveitis without corneal ulceration	
Proparacaine	—	See proxymetacaine	243
Proxymetacaine (proparacaine) (0.5%) (Ophthaine, Squibb)	Topical ³³⁰	Topical anesthetic	
Tetracaine (6%) (Ophtocain)	Topical ³³⁰	Topical anesthetic	
Tetracycline (Achromycin, Storz/Lederle)	Topical ⁷	Psittacines/ <i>Chlamydophila</i> , <i>Mycoplasma</i> ; treatment should include systemic antibiotics	
Tissue plasminogen activator (rTPA) (TNKase Tenecteplase, Genetech)	50 µg by injection ³²⁹	Raptors/hyphema (use paracentesis into the anterior eye chamber); intraocular hemorrhage (use intravitreal injection)	
Triamcinolone (Vetalog, Fort Dodge)	0.1–0.25 ml subconjunctival injection ²⁷⁰	Raptors/traumatic anterior uveitis without corneal ulceration in patients for which restraint is a concern	
d-Tubocurarine (Curarin-Asta, Asta-Werke, Bielefeld, Germany)	—	Mydriatic agent ^a ; recommended for therapeutic use only; administer into anterior chamber; high risk of intraocular injury; topical application has no effect ³²⁷	
	0.01–0.03 ml of 0.3% solution, intracameral ^{64,328,426}	Most species, including pigeons, raptors/dilation within 15 min, duration 4–12 hr	
Tylosin (Tylan Soluble Powder, Elanco)	Topical (mix powder 1:10 with sterile water) ⁷	Cockatiels/conjunctivitis; use in conjunction with systemic treatment	
Vecuronium bromide (Norcuron, Organon)	—	Mydriatic agent; may cause respiratory paralysis or shallow breathing, ataxia, death (especially when applied bilaterally ⁴⁰⁹); neostigmine may counteract systemic effects ^a	
	0.96 mg/bird topical ⁴⁹⁵	Cockatoos/use caution with bilateral application	
	0.096 mg/bird of 0.08% solution topical ⁴⁹⁵	Cockatoos, blue-fronted Amazon parrots, African grey parrots/PD	
	0.24–0.28 mg/kg topical ⁴⁹⁵	Blue-fronted Amazon parrots/PD	
	0.18–0.22 mg/kg topical ⁴⁹⁵	African grey parrots/PD	
	0.18–0.29 mg/kg topical ⁴⁹⁵	Cockatoos/PD	243
	2 drops of 0.4% solution topical q15min × 3 treatments ⁴⁰⁹	European kestrels/PD; maximal effect in 65 ± 12 min in falcons	244
	0.5% solution topical ^{124,409}	Raptors/duration 1 hr	
	1 drop of 0.4% solution topical ⁶⁴¹	Cormorants, loons/dilation at 30–45 min; duration >2 hr	
Vecuronium (V)/nitrous oxide (N)/isoflurane (I)	(V) 0.2 mg/kg IV + 1:1 ratio of oxygen to 33% (N) at 0.3 L/kg/min + (I) 1.0%–2.4% ^{327,328}	Most species/mydriasis and anesthesia; gases are administered by air sac cannulation; vecuronium effective up to 256 min in pigeons ^a	
<p>^a Variable amounts of skeletal muscle are present in the avian iris, giving birds voluntary control over pupil dilation. In many avian patients, the pupils are best dilated by restraining the animal in a dark room.</p>			244

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TABLE 31 Oncologic agents used in birds.

Agent	Dosage	Species/Comments
Acemannan (Carravet, Carrington Laboratories)	1 mg/kg SC q7d × 4 treatments ⁶⁴⁶ 2 mg/kg intralesional q7d × 4 treatments ⁶⁴⁶	Cockatoo/chemotherapeutic adjunct therapy Cockatoo/use before surgical debulking in fibrosarcoma
Asparaginase (Elspar, Merck)	400 IU/kg IM q7d ¹⁹⁹ 1650 IU/kg SC once ⁵⁴⁵	Cockatoo/lymphosarcoma; premedicate with diphenhydramine Great horned owl/sarcoma; associated with severe bone marrow suppression
Carboplatin (Paraplatin, Bristol-Meyers Squibb)	5 mg/kg IV over 3 min ³⁸⁴ 125 mg/m ² IV (slow bolus) q14–21d ⁶⁵⁶ 5 mg/kg intralesional ⁶⁴⁶	Sulphur-crested cockatoo/PD; mix with 5% dextrose to 400 mg/L; budgerigar/renal adenocarcinoma (leg paresis showed improvement over 2 mo; mass continued to grow); mix with saline Amazon parrot/dilute with 5% dextrose ^a Amazon parrot/squamous cell carcinoma; mix with sesame oil or plasma at a concentration of 10 mg/ml
Chlorambucil (Leukuran, Catalytic Pharmaceutical)	1 mg/bird PO 2×/wk ⁴³⁹ 2 mg/kg PO 2×/wk ⁵²³	Pekin duck/lymphocytic leukemia or lymphosarcoma; responded to treatment initially, but was euthanatized 1 mo after presentation because of respiratory distress and hemorrhages Umbrella cockatoo/cutaneous lymphosarcoma
Cisplatin (Platinol-AQ, Bristol-Myers Squibb)	1 mg/kg IV over 1 hr ^{164,165}	Cockatoo/PD; may cause nephrotoxicity; administer IV fluids 1 hr before and 2 hr after infusion
Cyclophosphamide (Cytoxan, Squibb)	200 mg/m ² IO q7d ¹⁹⁹ 300 mg/m ² PO once ⁵⁴⁵	Cockatoo/lymphosarcoma ^a Great horned owl/sarcoma ^a ; dose associated with severe bone marrow suppression
Diphenhydramine	2 mg/kg IO once ¹⁹⁹	Cockatoo/before chemotherapy
Doxorubicin (Doxil, Sequus Pharmaceuticals)	2 mg/kg IV ¹⁶⁶ 30 mg/m ² IO q2d ¹⁹⁹ 60 mg/m ² IV q30d ¹³⁹	Cockatoo/PD; may produce transient inappetence; frequency was not determined Cockatoo/lymphosarcoma ^a ; premedicate with diphenhydramine Blue-fronted Amazon parrot/osteosarcoma ^a ; premedicate with diphenhydramine 30 min before; dilute with saline and give over 30 min (anesthesia recommended)
Hexylether pyropheophorbide-a (Photochlor, Roswell Park Cancer Institute)	0.3 mg/kg IV ⁵⁹³	Hornbill/photosensitizing agent; use 24 hr before photodynamic therapy
Porfimer sodium (Photofrin, QLT PhotoTherapeutics)	3 mg/kg IV ⁵³²	Cockatiel/photodynamic therapy
Prednisone (Pediapred, Fisons)	1.6 mg/kg PO q24h ⁵⁴⁵	Great horned owl/sarcoma
Silymarin (milk thistle)	100–150 mg/kg PO divided q8–12h ²⁰	Hepatic antioxidant; use in patients with liver disease and as ancillary to chemotherapy; use a low-alcohol or alcohol-free liquid formulation

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Vincristine sulfate (Oncovin, Lilly)	0.5 mg/m ² IV, then 0.75 mg/m ² q7d × 3 treatments ⁴³⁹	Duck/lymphoma; lymphocytic leukemia ^a
	0.75 mg/m ² IO q7d × 3 treatments ¹⁹⁹	Cockatoo/lymphosarcoma ^a
	0.1 mg/kg IV q7–14d ⁵²³	Monitor CBC weekly
0.5 kg = 0.06 m ²		
1.0 kg = 0.10 m ²		
2.0 kg = 0.15 m ²		
3.0 kg = 0.20 m ²		
4.0 kg = 0.25 m ²		
5.0 kg = 0.29 m ²		

a Body weight (kg) = surface area (m²)

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TABLE 32 Antimicrobial-impregnated polymethylmethacrylate (PMMA) agents used in birds.^{a,160,385,595,637}

Agent	Dosage	Species/Comments
Bone cement (Surgical Simplex P Radiopaque Bone Cement, Howmedica)	—	Polymer powder and liquid monomer for use in making antibiotic impregnated beads ⁶³⁷
Amikacin (Amikacin powder, Dongyang Lantian Chemical)	1.25–2.5 g in 20 g polymer powder ¹⁶⁰	PD/elution of amikacin from PMMA beads was greater when the powdered form was used compared with liquid amikacin
Cefazolin (Ancef, SmithKline Beecham)	1–2 g in 20 g polymer powder ²⁹⁴	
Cefotaxime (Claforan, Hoechst Marion Roussel)	2 g in 20 g polymer powder ²⁹⁴	Mix antibiotic powder with bone cement powder, then add liquid for mixing
Ceftazidime (Fortaz, Tazicef, Glaxo Wellcome)	2 g in 20 g polymer powder ²⁹⁴	Mix antibiotic powder with bone cement powder, then add liquid for mixing
Ceftiofur (Naxcel, Pharmacia & Upjohn)	2 g in 20 g polymer powder ¹⁶⁰	Studies show elution for approximately 7 days only ¹⁰³
Clindamycin (Antirobe, Upjohn)	—	PMMA beads with clindamycin had adequate drug levels for more than 90 days ^{385,515}
Enrofloxacin (Baytril, Bayer)	—	Raptors/pododermatitis ⁵¹⁵
Gentamicin (Gentocin, Schering)	1 g powder or solution in 20 g polymer powder ¹⁶⁰ 1 ml of 50 mg/ml solution in 20 g polymer powder ⁶³⁷	Nephrotoxicity is an uncommon but possible side effect of local gentamicin treatment ⁶²³ PD/elution concentration remained greater than MIC for common pathogens for 30 days; powdered and liquid forms of gentamicin had similar elution rates from PMMA ¹⁶⁰ Raptors/pododermatitis
Gentamicin (Septopal, Merck)	Premade beads (product insert) ⁴⁸⁶	Commercially available in Europe; not available in the United States
Hydroxyapatite cement (BoneSource, Osteogenics)	—	Polymer powder used as an alternative to bone cement; absorbs into muscle and tissue; osteoconductive in bone; fabricates with water which aids in formulation with liquid antibiotics ¹⁶⁰
Itraconazole (Sporanox, Janssen)	16% itraconazole-impregnated PMMA fed as grit stones ⁵⁸³	Indian peafowl/PD; antifungal agent; when used as grit, therapeutic levels achieved in 2 days and decreased over 7 days; beads from capsules mix into PMMA uniformly before hardening; PMMA cut into 1-g size pieces (grit stone size) after hardening
Oxytetracycline (Liquamycin, Rogar/STC)	4.5 ml of 200 mg/ml solution in 20 g polymer powder ⁶³⁷	Raptors/pododermatitis
Rifampicin (R) (Rimactane, Ciba)/pefloxacin (P) (Pelwin, 5% soluble powder, Wockhardt)	1 part (R) + 1 part (P) finely ground in equal volumes in a mortar and pestle; thoroughly mix with 5 parts PMMA powder ⁵¹⁵	Rifampicin powder taken from oral capsules; pefloxacin powder obtained from the preparation intended for oral use in poultry
Rifampicin (R) (Rimactane, Ciba)/piperacillin (P) (Piperacil, Lederle)	1 part (R) + 1 part (P) combined and finely ground in a mortar and pestle; thoroughly mix with 5 parts PMMA powder ⁵¹⁵	Rifampicin powder taken from oral capsules; piperacillin powder taken from parenteral preparation before reconstitution

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- Choose antibiotic based on culture and sensitivity.
- Mix 1–2 g of sterile antibiotic powder with 40–60 g of PMMA powder. Add approximately 2 Tbs to antibiotic at a time. The use of liquid antibiotic reduces the mechanical strength of the bead.
- Shake mixture well (for at least 2 min) to make it homogeneous.
- Add liquid monomer as usual.
- The dough is placed in a catheter tip syringe and extruded, rolled into beads, and placed onto steel surgical wire. Dough may also be injected into a red rubber catheter that may be cut into variable sizes. The smaller the bead, the greater the elution of antibiotic.
- Gas sterilization is recommended; beads are aerated for at least 24 hr at room temperature.
- The wound is aggressively debrided and beads are placed within it; the wound is then closed and the beads are left within the site until the wound is no longer infected.^{595,637}
- In human medicine, beads are removed after 2–6 wk. Despite their antibiotic release, beads act as a surface to which bacteria preferentially adhere, grow and potentially develop antibiotic resistance.⁴³⁸ Beads are difficult to remove if left in place for more than 14 days.⁴⁶⁰
- Discard unused beads after 2 mo.⁵¹⁵

a Antimicrobial-impregnated polymethylmethacrylate is used to elute antimicrobial agents for long-term treatment of infected lesions. Following are guidelines for its use and preparation:

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TABLE 33 Agents used in the treatment of oiled birds.⁴¹²

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Agent	Dosage	Species/Comments
Bismuth subsalicylate	2–5 mg/kg PO once	Adsorbent; gavage; alternatively, can use activated charcoal
Charcoal, activated (Toxiban, Vet-A-Mix)	52 mg/kg PO once	Adsorbent; gavage; alternatively, can use bismuth subsalicylate
Detergent (Dawn, Procter & Gamble)	1%–5% bath	Submerge bird up to mid-neck region; rinse with water; use water at 103° F–105° F (39° C–41° C) and 40–60 psi
Fluid therapy	—	See Appendixes 33 and 34 for guidelines
Iron dextran	10 mg/kg IM q5–7d	If PCV < 25%
Vitamin B ₁ (thiamine)	25–30 mg/kg feed fish	Piscivores

psi, Pounds per square inch.

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TABLE 34 Agents used in bird emergencies.

Agent	Dosage	Species/Comments
Atropine sulfate (Abbott)	0.2 mg/kg IM, IV, IO ⁵⁰³ 0.5 mg/kg IM, IV, IO, IT ⁵⁴¹	Bradycardia CPR
Aminophylline (Aminophylline Roxane; Watson)	4 mg/kg PO q6–12h ⁶¹¹ 10 mg/kg IV q3h ⁶¹¹	Can give orally after initial response Use for pulmonary edema
Calcium gluconate (Calcium Gluconate, Lilly; Roxane; Fort Dodge)	50–100 mg/kg IM, IV (slow bolus) ^{272,303,518}	Hypocalcemia; dilute 50 mg/ml; hyperkalemia; facilitates potassium movement across cell membranes ³⁰³
Dexamethasone Na phosphate (Butler; Vedco; Dexaject SP, Vetus)	2–6 mg/kg IM, IV q12–24h ^{293,538,611}	Head trauma (until signs abate); shock (one dose); hyperthermia (until stable)
Dextrose (50%)	50–100 mg/kg IV (slow bolus to effect) ^{542,611} 500–1000 mg/kg IV (slow bolus) ^{94,491}	Hypoglycemia; can dilute with fluids Hypoglycemia; can dilute with fluids
Dextran 70 (McGaw)	10–20 ml/kg ¹⁰⁶	Most species/hypovolemic shock
Diazepam (Valium, Roche)	0.5–1.0 mg/kg IM, IV prn ⁵³⁹	Seizures
Doxapram (Dopram-V, Aveco)	5–10 mg/kg IM, IV once ²⁷⁰ 20 mg/kg IM, IV, IO ⁵³⁸	Raptors/respiratory depression or arrest CPR; respiratory depression
Epinephrine (1:1000)	0.5–1.0 ml/kg IM, IV, IO, IT ^{538,541}	CPR; bradycardia
Fluids	10–25 ml/kg IV, IO ⁶⁴⁵ 50–90 ml/kg fluids SC, ^a IV, IO ⁵⁴²	Bolus over 5–7 min See Appendixes 33 and 34 (fluid therapy)
Hemoglobin glutamer-200 (Oxyglobin, Biopure)	— 3–10 ml/kg IV (slow) ⁶ 5 ml/kg IV ³⁵² 10 ml/kg IV ²⁷⁰ 15 ml/kg IV ⁶	Hemoglobin replacement product Most species Mallard ducks Raptors Chickens/PD; hemoglobin levels fell near zero by 50 min after administration
Hetastarch (Hespan, DuPont)	10–15 ml/kg IV (slow) q8h ^{270,303,587} 1–4 treatments	Most species, including raptors/hypoproteinemia; hypovolemia
Mannitol (Manniject, Vetus; Mannitol Injection, Vedco)	0.2–2.0 mg/kg IV (slow) q24h ^{270,303}	Raptors/cerebral edema; anuric renal failure
Oxyglobin	—	See hemoglobin glutamer-200
Prednisolone Na succinate (Solu-Delta-Cortef, Upjohn)	10–20 mg/kg IM, IV q15min prn ⁹⁴ 15–30 mg/kg IV ³⁰³	Head trauma; CPR Raptors
Sodium bicarbonate (Butler)	1 mEq/kg q15–30min to maximum of 4 mEq/kg total dose ⁶¹³ 5 mEq/kg IV, IO once ⁵³⁸	Metabolic acidosis CPR

a Because of the presence of peripheral vasoconstriction, subcutaneous administration is not adequate for patients in shock.

TABLE 35 Euthanasia agents used in birds.^a

Agent	Dosage	Species/Comments
Carbon dioxide (CO ₂)	70% ⁵⁵³	Most species/danger to person administering gas; compressed gas is the only recommended source ¹⁵
Carbon monoxide (CO)	Minimum 6% concentration in a closed container ⁵⁵³	Most species/unconsciousness occurs rapidly; inexpensive ⁴²¹ ; danger to person administering gas; compressed gas recommended
Halothane (Halothane, Rhône Meriéux; Fluothane, Fort Dodge)	Saturated cotton ball in closed container or face mask ^{481,553}	Most species/very rapid induction; wing flapping and vocalizing may occur
Isoflurane (Aerrane, Anaquest)	Saturated cotton ball in closed container or face mask ^{481,553}	Most species/very rapid induction; wing flapping and vocalizing may occur
Methoxyflurane (Metofane, Schering)	Saturated cotton ball in closed container or face mask ^{481,553}	Most species/induction may be slower than with halothane or isoflurane
Pentobarbital sodium (Beuthanasia-D solution, Schering)	0.2–1.0 mL/kg IV, ICe ^{476,538}	Most species/birds may react unpredictably with IV administration; ICe administration is smooth, quiet
Potassium chloride	1–2 mmol/kg ¹⁵	Must be provided in conjunction with prior general anesthesia

^a The American Veterinary Medical Association accepts inhalant anesthetic overdose, carbon monoxide, carbon dioxide, and barbiturate overdose as humane euthanasia methods.⁵⁵³ Cervical dislocation and decapitation are conditionally acceptable for research and poultry. Pithing should be used as an adjunctive procedure to ensure death in an animal already rendered unconscious by another method.¹⁵

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TABLE 36 Miscellaneous agents used in birds.

Agent	Dosage	Species/Comments
Acemannan (Hydrogel wound dressing with acemannan: Carravet, Veterinary Products Labs)	Topical ¹⁶³	Most species/wound healing; increases cytokine production, fibroblast proliferation, and epidermal growth ^a
Allopurinol (Zyloprim, GlaxoWellcome)	—	Xanthine oxidase inhibitor; use in gout is controversial: 50 mg/kg given to red-tailed hawks was toxic, leading to marked elevations in plasma oxypurinol, xanthine, and hypoxanthine with secondary renal dysfunction ³⁷⁵ ; maintain hydration ⁵⁴⁶
	10 mg/kg PO q4–12h ⁵³⁶	Most species/prepare suspension; reduce dose as uricemia decreases
	10–15 mg/kg PO ⁷²	Psittacines, passerines, raptors
	25 mg/kg PO q24h ^{474,475}	Red-tailed hawks/PD; no significant effect on plasma uric acid levels
	30 mg/kg PO q12h ³⁴	Most species/gout
	830 mg/L drinking water ⁵³⁸	Most species
	1 ml stock solution/30 ml drinking water mixed fresh several times daily (300 mg/L) ⁵¹⁹	Budgerigars/decrease initial dose to 25% recommended dose in severe cases and gradually increase over several days; use with colchicine in severe cases; stock solution: 100 mg tablet/10 ml sterile water
Aloe vera (Dermaide Aloe, Dermaide Research Corp)	Topical ^{163,293}	Most species/antiinflammatory; antithromboxane activity; beneficial in treating burns, electrical injury, or drying skin flaps ^a ; see heparin for combination
Aluminum hydroxide (Amphojel, Wyeth-Ayerst)	30–90 mg/kg PO q12h ⁵³⁸	Most species/antacid; phosphate binder
Aminoloid (Aminoloid, Schering)	0.25–0.75 mg/kg IM, repeat in 10–14 days ⁵⁴⁶	Raptors/induction of molt
Aminopentamide hydrogen sulfate (Centrine, Fort Dodge; Aveco)	0.05 mg/kg SC, IM q12h up to 5 doses ¹⁷⁵	Most species/regurgitation
	0.11 mg/kg SC, IM q8–12h × 1 day, then q12h × 1 day, then q24h × 1 day ⁵³	Most species/regurgitation
Aminophylline (Roxane; Watson)	4 mg/kg PO, IM q6–12h ⁵³⁸	Most species/bronchodilator; prepare suspension
	5 mg/kg PO, IV q12h ³⁵¹	Psittacines
	8–10 mg/kg PO, IM, IV q6–8h ^{270,612}	Raptors, ratites
	10 mg/kg IV q3h, then PO after initial response ^{245,519}	Most species
	10 mg/kg IM, IV q8–12h ²⁴⁵	Most species/for IV use, dilute in 10–20 ml saline or 5% dextrose in water and inject slowly
Ammonium solution	Topical prn ⁵¹⁹	Most species/analgesic; antipruritic; antiinflammatory; can use on fresh wounds; avoid overuse ^a

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9,10 Anthraquinone (Flight Control, Environmental Biocontrol Intl)	12.6 ml/L water sprayed q7d on dry, grassy areas where geese frequent ⁵⁹⁴	Nuisance Canada geese/deterrent if ingested; birds become nauseated and subsequently avoid the area, which contains an ultraviolet dye readily detected by the avian eye	
Anticoagulant citrate dextrose (A-C-D Solution, Sanofi)	0.15 ml/1 ml whole blood ²⁸⁴	Anticoagulant for transfusions; not effective for extended storage of whole blood ⁴²⁰ ; heparin can be substituted if A-C-D is not available ²⁸⁴	
Armor All Protectant (Armor All Protectant Corp)	Topical to affected plumage ⁴⁰	Most species/soften sticky-trap glue-covered plumage; use Dawn dish detergent to remove Armor All	
Barium sulfate (Barotrast, Rhône-Poulenc; Novopaque, Picker International)	— 20–25 ml/kg PO via gavage ^{209,627} 25–50 ml/kg PO ²⁰⁹	Dilute 72% suspension 1:1 with water; dilute 92% suspension 1:2 with water; 60% suspension effective in Amazon parrots ¹⁵⁷ ; more dilute concentrations (20%–25%) can also be used ^b ; administer ½ volume diluted barium and ½ volume air for double contrast study of crop ⁴⁰⁴ Most species Smaller species require relatively more contrast media; African grey parrots, 25 ml/kg; Quaker parakeets and budgerigars, 50 ml/kg	254
Bismuth subsalicylate (Pepto Bismol, Procter & Gamble; Bismusal, Bimeda)	1–2ml/kg PO q12h ^{335,546,610} 2–5 ml/kg PO once ⁴¹²	Most species/weak adsorbent, demulcent A component of oiled bird treatment; alternatively can use activated charcoal	255
Bromhexine HCl (Bisolvon, Boehringer Ingelheim)	1.5 mg/kg IM q12–24h ⁹⁴ 3–6 mg/kg IM ^{55,106} 6.5 mg/L drinking water ¹⁰⁶ 1200 mg/L drinking water ⁵⁵	Most species/expectorant Most species, including psittacines, passerines, raptors Psittacines Most species	
Cimetidine (Tagamet, SmithKline Beecham)	3–5 mg/kg PO, IV q8h ⁶¹² 5 mg/kg PO, IM q8–12h ⁵³⁸ 5–10 mg/kg IM q12h ⁶¹²	Ratites Psittacines/proventriculitis; gastric ulceration Ratites	
Cisapride (Propulsid, Janssen)	— 0.25 mg/kg PO q8h ¹⁰⁷ 0.5–1.5 mg/kg PO q8h ^{293,519} 1 mg/kg PO q12h ¹³⁸	No longer commercially available in the United States Raptors/gastrointestinal stimulant Most species Psittacines/ileus	
Citrate phosphate dextrose adenine solution (CPDA)	1 part CPDA:5 parts whole blood ⁴²⁰	Anticoagulant for blood collection for transfusion; not for extended storage of whole blood	
Citric acid	5000 mg/L drinking water ¹⁰⁶	Most species/reduces the effect of calcium and magnesium on the absorption of tetracyclines	

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Colchicine (Colchicine, Abbott)	—	Unique antiinflammatory used in the treatment of gout or hepatic fibrosis/cirrhosis ⁴⁷³ ; may potentiate gout formation in some cases ⁵¹⁸ Juvenile macaws/gout Most species/gradually increase to q12h ⁶¹¹ Psittacines	
	0.01 mg/kg PO q12h ¹⁰⁰ 0.04 mg/kg PO q12–24h ²⁶³ 0.2 mg/kg PO q12h ⁵¹⁹		
Copper sulfate (Cu-7, Searle)	Topical ⁵⁴⁶	Most species/ulcerative dermatitis	255
Detergent (Dawn, Procter & Gamble)	1%-5% bath ⁵³⁸	Most species/Armor All, motor oil removal	256
Dextran 70 (McGaw)	10–20 ml/kg IV ¹⁰⁶	Most species/hypovolemic shock; colloid with a $T_{1/2}$ shorter than hetastarch	
Digoxin (Lanoxin, GlaxoWellcome; Digoxin, Wyeth-Ayerst)	—	Toxic reactions include depression, ataxia, vomiting, diarrhea; contraindicated with renal or liver disease ³³² ; monitoring of serum digoxin, potassium, magnesium, calcium, and ECG is recommended; induced arrhythmias in pigeons at 0.2 mg/kg/day ⁴¹³ Turkeys Poultry Chickens/ascites syndrome; reduced ascites; no apparent toxicity Psittacines, passerines, raptors/congestive heart disease Pekin ducks Parakeets, sparrows (PD)/produces a plasma concentration of 1.6 µg/ml (within mammalian therapeutic range); this dose led to signs of toxicity in a mynah ⁵³⁴ Quaker parakeets/PD; congestive heart failure; cardiomyopathy Psittacines, passerines, raptors/congestive heart disease	
	0.0035 mg/kg IV q24h ¹¹ 0.0049 mg/kg IV q12h ¹¹ 0.01 mg/kg PO q24h × 6 wk ¹⁴ 0.01–0.02 mg/kg PO q12h ¹⁰⁶ 0.019 mg/kg IV q12h ¹¹ 0.02 mg/kg PO q24h × 5 days ²²⁹ 0.05 mg/kg PO q24h ⁶⁴⁸ 0.13 mg/L drinking water ¹⁰⁶		
Dimethylsulfoxide (90%) (DMSO, Univet; DOMOSO, Syntex)	1 ml/kg topical to affected area q4–7d ⁵¹⁸	Most species/antiinflammatory, analgesic; systemic absorption; use gloves during application	
Diocetyl Na sulfosuccinate (Diocto, Barre)	33 ml/L drinking water ³⁰⁶	Psittacines (chicks)/constipation; use only if chick is drinking	
Diphenhydramine (Benadryl, Parke-Davis)	1–4 mg/kg PO q8h ⁵³⁸	Macaws, Amazon parrots/allergic rhinitis, hypersensitivity	256
	2 mg/kg IV, IO once ¹⁹⁹ 2–4 mg/kg IM, IV q12h ²⁹³ 20–40 mg/L drinking water ²⁰⁵	Cockatoos/use before chemotherapy Most species Most species	257
Diphenoxylate with atropine (Lomotil, Searle)	2.0–2.5 mg/kg PO q8h ⁶¹²	Ratites/opiate; gastrointestinal motility modifier	

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EDTA-tromethamine or EDTA-Tris	IT, intranasal, or wound lavage ⁵⁴⁶	Most species/potentiates the effect of antibiotics on resistant bacteria ¹⁶² ; 1.2 g EDTA +6.05 g Tris added to 1 L sterile water, pH adjusted to 8.0 with a dilute solution of sodium hydroxide, autoclaved × 15 min; Tris-EDTA may also be added to chlorhexidine solution ²²
Enalapril (Enacard, Merck; Vasotec, Merck)	0.25–0.5 mg/kg PO q24–48h ^{21,476}	Psittacines/dilated cardiomyopathy; monitor uric acid levels; reduce dose or discontinue if concurrent renal disease
Ferric subsulfate	Topical ⁵¹⁹	Most species/hemostasis of bleeding nail or beak tip; will cause necrosis if used on open skin lesions
Furosemide (Furosemide, Roxane)	— 0.1–2.0 mg/kg PO, SC, IM, IV q6–24h ^{332,518,546} 0.15 mg/kg IM ³⁰⁶ 0.15 mg/kg IM q8h ³¹³ 0.5–1.0 mg/kg IM q12–24h ^{72,611} 1.0–2.2 mg/kg PO q12–24h ^{444,534,539} 2–5 mg/kg IM ^{270,303} 2.5–10.0 mg/kg PO q12h × 7–14 days ⁵³⁸	Diuretic; overdose can cause dehydration and electrolyte abnormalities; toxicity characterized by neurologic signs and death ⁵⁴⁶ Most species, including psittacines, raptors/lories are extremely sensitive ^{518,611} Psittacines (neonates)/pulmonary congestion Mynahs/ascites, hemochromatosis Pigeons, raptors, mynahs, ostriches/cardiac disease, ascites Psittacines Raptors Cockatiels, budgerigars/ascites
	4–6 mg/kg PO, IM ⁵⁰² 40 mg/L drinking water ⁵³⁸	Raptors/pulmonary congestion Most species/congestive heart failure; can be used with digoxin and ACE inhibitors
Gadopentate dimeglumine (Magnevist, Berlex)	0.25 mmol/kg IV ⁵²⁸	Contrast agent for magnetic resonance imaging
Gallium-67 citrate (Ga-67)	0.5 mCi (microcuries)/bird IV ³¹⁰	Green-winged macaw/radiopharmaceutical used for detection of infection and inflammatory lesions; requires a gamma camera for imaging
Gemfibrozil (Lopid, Parke-Davis)	30 mg/kg PO q8h ⁴⁸⁹	Psittacines/lipid-regulating agent; yolk emboli; sometimes effective in controlling signs; gradual improvement may be seen over wk to mo; give with niacin
Gentian violet/crystal violet	Topical ¹⁰⁷	Raptors/wound management
Glipizide (Glucotrol, Roerig)	— 0.5 mg/kg PO q12h ⁴⁷⁷ 1.25 mg/kg PO q24h ²⁹³	Diabetes mellitus; contraindicated in ketotic patients; patients should be maintained at trace glucosuria to prevent hypoglycemia ⁴⁷⁷ Cockatiels/diabetes mellitus Most species/diabetes mellitus
Glycosaminoglycan	—	See polysulfated glycosaminoglycan

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Guaifenesin (Guailaxin, Fort Dodge)	0.8 mg/kg PO q12h ⁴⁷²	Severe macaw/expectorant, bronchodilation	
Hemoglobin glutamer-200 (Oxyglobin, Biopure)	— 3–10 ml/kg IV (slow) ⁶ 5 ml/kg IV ³⁵² 10 ml/kg IV ²⁷⁰ 15 ml/kg IV ⁶	Hemoglobin replacement product; mean 2.7 ± 1.9 ml/kg IV administered to cockatiels to replace blood (1.6–2.5 ml) removed by phlebotomy; 2 of 11 birds died; no adverse reactions were recognized in surviving birds ³⁵³ Most species Mallard ducks/PD Raptors Chickens/PD; hemoglobin levels fell near zero by 50 min after administration	258
Heparin	2 U/ml whole blood ¹³⁰	Cockatiels, conures/anticoagulant for blood transfusions	259
Heparin/aloe vera	Topical to affected area ²⁹³	Most species/antiinflammatory; dilute 1000 IU heparin/150 mg aloe vera ^a	
Hetastarch (Hespan, DuPont)	— 10–15 ml/kg IV q8h × 1–4 treatments ^{270,303,587}	Colloid with a T _{1/2} of 25 hr; use with caution in patients with congestive heart failure or renal failure Most species/chronic hypoproteinemia; decrease fluid treatment to 1/3–½ maintenance fluid dose	
Hyaluronidase (Wydase, Wyeth-Ayerst)	5 IU/kg IV q12h × 1–3 days then 2×/wk prn ³⁵⁷ 75–150 IU/L fluids ^{303,357}	Psittacines/egg yolk–related disease; egg yolk visually apparent in blood or serum; dilute with an equal or greater quantity of isotonic NaCl Most species/increases absorption rate of fluids ²⁰¹	
Hydroxyzine (Atarax, Roerig)	2.0–2.2 mg/kg PO q8h ^{214,334} 34–40 mg/L drinking water ^{205,214}	Amazon parrots/allergic pruritus; feather picking; self-mutilation Most species/respiratory allergy; feather picking	
Iohexol (Omnipaque, Sanofi Winthrop)	25–30 ml/kg PO ^{157,209} 50 ml/kg PO ²⁰⁹	Cockatoos, Amazon parrots/gavage; radiographic gastrointestinal iodinated contrast media; 1:1 dilution with water can also be used Quaker parakeets, budgerigars	
Isoxsuprine (Vasodilan, Mead Johnson)	5–10 mg/kg PO q24h × 20–40 days ⁴⁴	Raptors/peripheral vasodilator; wing tip edema	
Kaolin/pectin (Kaopect, Med-Tech)	2 ml/kg PO q6–12h ^{34,546} Up to 15 ml/kg PO, repeat prn ¹⁰⁷	Psittacine neonates/intestinal protectant, antidiarrheal Raptors	259
Lactulose (Cephulac, Marion Merrell Dow)	— 150–650 mg/kg (0.2–1.0 ml/kg) PO q8–12h ^{34,388,546,611} 200 mg/kg (0.3 ml/kg) PO q8–12h ³⁰⁵ 300 mg/kg PO q12h ⁴⁵⁰	Reduces blood ammonia levels; increases gram positive in the gastrointestinal tract; exerts osmotic effect in birds with caeca through fermentation to acetic and lactic acid ⁴⁷³ Most species, including psittacines/hepatic encephalopathy Psittacines (neonates) Chatterly lories	260
Magnesium hydroxide (M)/activated charcoal (C) (Milk of Magnesia, Roxane)	(M) 10–12 ml +(C) 1 tsp powder ³³⁵	Most species/cathartic; adsorbent	

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Magnesium sulfate (Epsom salts)	—	Purgative, cathartic; may cause lethargy ³³⁵ ; see peanut butter for combination Most species, including raptors
	0.25–1.0 g/kg PO q24h × 1–2 days ^{107,335}	
	¼ tsp/bird ⁶¹²	Ratites (juveniles)/obstipation
	2 Tbs/bird ⁶¹²	Ratites (adults)/obstipation
Mannitol (Manniject, Vetus; Mannitol Injection, Vedco)	—	Osmotic diuretic used to treat cerebral edema, especially after head trauma; may be used with furosemide Most species, including raptors
	0.25–2.0 mg/kg q24h IV (slow bolus) ^{303,518}	
	1500 mg/kg IV q6h ⁶¹²	Ratites
Methocarbamol (Robaxin-V, Fort Dodge)	32.5 mg/kg PO q12h ⁵¹⁹	Swans, cranes (Demoiselle)/capture myopathy
	50 mg/kg IV (slow bolus) ^{102,519}	Most species, including swans, Demoiselle cranes/muscle relaxation; capture myopathy; give slow bolus IV; may be given q12h for muscle relaxation
Metoclopramide (Reglan, Robins)	—	Gastrointestinal motility disorders, regurgitation, slow crop motility; no alterations in motility observed after a single dose of 1 mg/kg IM ⁶⁰ Ostriches
	0.1 mg/kg IV ⁶¹²	Most species
	0.3 mg/kg PO, IM, IV ³⁹⁶	
	0.5 mg/kg q8–12h PO, IM, IV ⁵¹⁸	Most species, including psittacines/gastrointestinal ileus; regurgitation
	2 mg/kg IM, IV q8–12h ^{44,86,508}	Raptors, waterfowl/crop stasis, ileus
	12.5 mg/kg PO ⁶¹²	Ratites/gastrointestinal disorders
Mineral oil	—	Cathartic; used to aid passage of grit and other foreign bodies; administer directly into the crop because oral administration may result in aspiration pneumonia; see peanut butter for combination
	Up to 5 ml/kg via gavage or per cloaca ^{107,241}	Most species, including psittacines, raptors
	5–10 ml/kg PO via gavage ^{335,611}	Most species, including psittacines/cathartic
	15 ml/kg PO via gavage ⁶¹²	Ratites (adults)/impaction
Oxyglobin	—	See hemaglobin glutamer-200
Peanut butter	Peanut butter and mineral oil (2:1) ³³⁵	Most species/add to diet; cathartic
	Dilute peanut butter and magnesium sulfate ³³⁵	Most species/add to diet; cathartic; dilute with water
Policosanol (Mountain States Health Products)	0.3–2.0 mg/day PO ¹⁸⁵	Psittacines/hyperlipidemia; use was reported in 2 birds
Polysulfated glycosaminoglycan (PSGAG) (Adequan, Luitpold)	5 mg/kg IM q7d ⁴⁷⁶	Pekin ducks/degenerative joint disease
	10 mg/kg IM, IA q7d × 3 mo ^{590,609}	Most species, including pheasants, vultures, cranes/noninfectious or traumatic joint dysfunction; 250 mg/ml for IA use; 500 mg/ml for IM use
	500 mg/bird IM q4d × 7 treatments ⁶¹²	Ratites

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Povidone iodine (Betadine Surgical Scrub, Purdue Frederick)	Topical, wash off within 5 min ⁴⁴	Raptors/wound cleansing	261
Probenicid (Benemid, MSD Pharmaceuticals)	—	Not currently recommended for the treatment of gout; may exacerbate the condition ⁴	262
	125 mg/kg PO q6h ¹⁰⁰	Macaws (chicks)/antigout	
Probucol (Lorelco, Marion Merrell Dow)	1 drop stock/300 g PO q12h × 2–4 mo ^{293,519}	Most species/low-density lipoprotein-cholesterolemia; contains iron: use cautiously in species susceptible to hemochromatosis; may increase bile acids; use with low-fat diet; prepare stock: crush 250 mg tablet/7.5 ml lactulose	
Propentofylline (Vivitonin, Hoechst)	5 mg/kg PO q12h × 20–40 days ¹⁰⁷	Raptors/wing-tip edema, dry gangrene syndrome	
Propranolol (Inderal, Wyeth-Ayerst)	0.04 mg/kg IV (slow) ⁵¹⁸ 0.2 mg/kg IM ⁵¹⁸	Most species/supraventricular arrhythmia, atrial flutter, fibrillation	
Psyllium (Metamucil, Procter & Gamble)	0.5 tsp/60 ml hand feeding formula ³³⁵ 1 Tbs/60 ml water/bird PO, up to 120 ml/day ⁶¹² 2 Tbs/10 kg PO ³⁰⁶	Most species/bulk diet; can use mineral oil as alternative or in addition to psyllium Ratites (chicks)/impaction Ostriches (neonates)/impaction	
Silymarin (milk thistle)	100–150 mg/kg PO divided q8–12h ²⁰	Hepatic antioxidant; use in patients with liver disease and as ancillary to chemotherapy; use a low-alcohol or alcohol-free liquid formulation	
Skin-So-Soft (Avon)	Topical to affected plumage ⁴⁰	Most species/softens and removes sticky-trap glue from plumage; use Dawn dish detergent to remove Skin-So-Soft product ^a	
Sucralfate (Carafate, Marion Merrell Dow)	25 mg/kg PO q8h ⁵¹⁸	Most species, including raptors/oral, esophageal, gastric, duodenal ulcers; give 1 hr before food or other drugs ⁶¹¹	
^{99m} Tc-technetium-disofenin (^{99m} Tc-ds, Hepatolite, DuPont Merck)	1 mCi (microcurie) ¹²⁹ in a commercial liquid or solid diet	African grey parrots/radionuclide used for gastrointestinal scintigraphy in birds	
^{99m} Tc-technetium-diethylene-triaminepenta-acetic acid (DTPA)	42 ± 0.16 MBq (1.158 ± 0.164 mCi [microcurie])/bird IV ³⁹¹	Pigeons/PD; radiopharmaceutical agent of choice for the assessment of renal function	262
Terbutaline (Brethine, Novartis)	0.01 mg/kg PO, IM q6h ³⁵¹ 0.1 mg/kg PO q12–24h ⁵³⁸	Psittacines/α ₂ -selective smooth muscle bronchodilator Macaws, Amazon parrots/bronchodilator; obstructive pulmonary disease, pneumonitis	263
Theophylline (Theophylline, Roxane; Theo-Dur, King)	2 mg/kg PO q12h ⁴⁷²	Severe macaws/bronchodilation	
Tincture of iodine	Topical ¹⁰⁷	Raptors/wounds; cheap, visible, readily available in undeveloped countries	
Tyrod's solution	Offer in place of drinking water ⁵¹⁹	Cockatiels/restores renalmedullary gradient; add 8 g NaCl, 0.13 g CaCl ₂ , 0.2 g KCl, 0.1 g MgCl ₂ , 0.05 g Na ₂ HPO ₄ , 1 g NaHCO ₃ , 1 g glucose to 1 L water	

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Trypsin-balsam of Peru-castor oil (Granulex, Pfizer)	Topical ¹⁶³	Digests necrotic tissue (may have debriding action); may have analgesic effects; may cause local inflammation and pyogenic reaction; do not use for long-term management ^a
Urate oxidase (Uricozyme, Sanofi Winthrop)	100–200 IU/kg IM q24h ^{474,475}	Red-tailed hawks, pigeons/PD; significantly lowered plasma uric acid, including postprandial plasma uric acid
Vegetable oil	15 mL/kg PO ⁶¹²	Ratites/impaction
Yeast cell derivatives (Preparation H, WhiteHall)	Topical q24h ⁶¹¹	Most species/pododermatitis; stimulation of epithelialization

- a Many topical agents contain oils that adhere to plumage. These agents should be used sparingly and generally in nonfeathered regions to prevent losing the insulative properties of the plumage.
- b Sander JE. Personal communication. 1996.

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APPENDIX 16 Hematologic and serum biochemical values of selected psittacines.^a

Measurement	African Grey Parrot ^{203,338,520,617}	Amazon Parrots ^{203,338,520,617}
HEMATOLOGY		
PCV (%)	43–55	45–55
RBC ($10^6/\mu\text{l}$)	2.4–4.5	2.5–4.5
Hb (g/dl)	11.0–16.0	12.2–15.9
MCV (fl)	90–180	160–175
MCH (pg)	28–52	47.2–56.8
MCHC (g/dl)	23–33	29.1–31.9
WBC ($10^3/\mu\text{l}$)	5–15	6–17
Heterophils (%)	45–75	30–75
Lymphocytes (%)	20–50	20–65
Monocytes (%)	0–3	0–3
Eosinophils (%)	0–2	0–1
Basophils (%)	0–5	0–5
H:L ratio	—	—
CHEMISTRIES		
AP (IU/L)	12–160	15–150
ALT (IU/L)	—	—
AST (IU/L)	100–350	130–350
Amylase (IU/L)	415–626	184–478
Bile acid ($\mu\text{mol/L}$)		
RIA	18–71	19–144
Colorimetric	12–96	33–154
Calcium (mg/dl)	8–13	8–13
Cholesterol (mg/dl)	160–425	—
CK (IU/L)	123–875	45–265
Chloride (mEq/L)	—	—
Creatinine (mg/dl)	0.1–0.4	0.1–0.4
GGT (IU/L)	1–10	—
Glucose (mg/dl)	190–350	220–350
LDH (IU/L)	150–450	160–420
Phosphorus (mg/dl)	3.2–5.4	3.1–5.5
Potassium (mEq/L)	2.6–4.2	3.0–4.5
Sodium (mEq/L)	134–152	136–152
Uric acid (mg/dl)	4–10	2–10
Protein, total (g/dl)	3–5	3–5
Albumin (g/dl)	1.57–3.23	1.9–3.5
Globulin (g/dl)	—	—
A:G ratio	1.6–4.3	1.9–5.9
Pre-albumin (g/dl)	0.03–1.35	0.35–1.05
α -globulin (g/dl)	0.02–0.27 (α_1)	0.05–0.32 (α_1)
	0.12–0.31 (α_2)	0.07–0.32 (α_2)
β -globulin (g/dl)	0.15–0.56	0.12–0.72
γ -globulin (g/dl)	0.11–0.71	0.17–0.76

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Measurement	Budgerigar Parakeet ^{34,203,261,617}	Caique ²⁰³	Cockatiel ^{33,203,338,617}
HEMATOLOGY			
PCV (%)	44–58	47–55	45–54
RBC ($10^6/\mu\text{l}$)	2.3–3.9	—	2.5–4.7
Hb (g/dl)	13–18	—	11–16
MCV (fl)	90–190	—	90–200
MCH (pg)	27–59	—	28–55
MCHC (g/dl)	22–32	—	22–33
WBC ($10^3/\mu\text{l}$)	3–8	8–15	5–13
Heterophils (%)	40–65	39–72	40–70
Lymphocytes (%)	20–45	20–61	25–55
Monocytes (%)	0–1	0–2	0–2
Eosinophils (%)	0–1	0–1	0–2
Basophils (%)	0–1	0–1	0–6
H:L ratio	0.9–3.3	—	0.7–2.8
CHEMISTRIES			
AP (IU/L)	10–80	—	0–346
ALT (IU/L)	—	—	0–9
AST (IU/L)	55–154	118–364	100–396
Amylase (IU/L)	302–560	244–290	—
Bile acid ($\mu\text{mol/L}$)			
RIA	20–65	—	25–85
Colorimetric	32–117	12–112	15–139
Calcium (mg/dl)	6.4–11.2	8.3–11.1	8.5–13.0
Cholesterol (mg/dl)	145–275	126–220	140–360
CK (IU/L)	54–252	124–384	30–245
Chloride (mEq/L)	—	—	—
Creatinine (mg/dl)	0.1–0.4	—	0.1–0.4
GGT (IU/L)	1–10	—	0–5
Glucose (mg/dl)	254–399	170–372	200–450
LDH (IU/L)	154–271	147–270	125–450
Phosphorus (mg/dl)	3.0–5.2	—	3.2–4.8
Potassium (mEq/L)	2.2–3.7	—	2.5–4.5
Sodium (mEq/L)	139–159	—	132–150
Uric acid (mg/dl)	3.0–8.6	2.5–10.7	3.5–11.0
Protein, total (g/dl)	2–3	2.5–3.5	2.4–4.1
Albumin (g/dl)	—	1.8–2.5	0.7–1.8
Globulin (g/dl)	—	0.9–1.7	—
A:G ratio	—	1.7–2.8	1.5–4.3
Pre-albumin (g/dl)	—	—	0.8–1.6
α -globulin (g/dl)	—	—	0.05–0.40 (α_1)
			0.05–0.44 (α_2)
β -globulin (g/dl)	—	—	0.21–0.58
γ -globulin (g/dl)	—	—	0.11–0.43

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Measurement	Cockatoos ^{98,203,279}	Conures ^{203,338,617}	Eclectus Parrot ^{97,203}
HEMATOLOGY			
PCV (%)	42–54	42–54	45–55
RBC ($10^6/\mu\text{l}$)	2–4	2.9–4.5	2.7–3.8
Hb (g/dl)	12–16	12–16	13.5–16.0
MCV (fl)	120–175	90–190	125–175
MCH (pg)	35–55	28–55	40–50
MCHC (g/dl)	28–33	23–31	29–32
WBC ($10^3/\mu\text{l}$)	5–13	4–13	9–20
Heterophils (%)	15–64	40–70	35–50
Lymphocytes (%)	29–83	20–50	45–65
Monocytes (%)	0–9	0–3	1–7
Eosinophils (%)	0	0–3	1
Basophils (%)	0–3	0–5	0–3
H:L ratio	0–2	0.8–3.8	1–2
CHEMISTRIES			
AP (IU/L)	24–104	24–250	32–111
ALT (IU/L)	0–5	5–13	0–5
AST (IU/L)	120–360	125–378	135–339
Amylase (IU/L)	228–876	192–954	562–684
Bile acid ($\mu\text{mol/L}$)	20–70	20–45	—
RIA	34–112	32–105	30–110
Colorimetric	8–11	8–15	8.8–9.8
Calcium (mg/dl)	150–300	120–400	220–325
Cholesterol (mg/dl)	140–410	35–355	132–625
CK (IU/L)	110–120	—	112–120
Chloride (mEq/L)	0.2–0.7	0.1–0.5	0.4–0.5
Creatinine (mg/dl)	0–4	1–15	1–5
GGT (IU/L)	200–300	200–350	225–300
Glucose (mg/dl)	150–1000	125–420	100–386
LDH (IU/L)	3.5–6.5	2–10	4.5–7.0
Phosphorus (mg/dl)	3–5	3.4–5.0	2.2–4.6
Potassium (mEq/L)	145–155	134–148	150–158
Sodium (mEq/L)	2.0–8.5	2.5–10.5	0.7–5.0
Uric acid (mg/dl)	3–5	2.5–4.5	4–5
Protein, total (g/dl)	1.0–1.6	1.9–2.6	1.4–1.8
Albumin (g/dl)	1.5–2.5	—	1.3–2.3
Globulin (g/dl)	0.6–2.36	2.2–4.3	0.52–1.79
A:G ratio	0.3–0.6	0.18–0.98	—
Pre-albumin (g/dl)	0.1–0.5	0.04–0.23 (α_1)	0.6–1.2
α -globulin (g/dl)	—	0.08–0.26 (α_2)	—
β -globulin (g/dl)	0.2–0.4	0.07–0.47	0.6–1.2
γ -globulin (g/dl)	0.5	0.12–0.61	0.6–1.2

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Measurement	Grey-Cheek Parakeet ³³⁸	Jardine's Parrot ⁶¹⁷	Lory ^{203,558}
HEMATOLOGY			
PCV (%)	45–58	35–48	47–55
RBC ($10^6/\mu\text{l}$)	—	2.4–4.0	3.3–4.0
Hb (g/dl)	—	11–16	10.8–14.8
MCV (fl)	—	90–190	28–31
MCH (pg)	—	25–56	—
MCHC (g/dl)	—	21–33	21–23
WBC ($10^3/\mu\text{l}$)	4.5–12.0	4–10	8–13
Heterophils (%)	40–75	55–75	40–60
Lymphocytes (%)	20–60	25–45	22–69
Monocytes (%)	0–3	0–2	0–2
Eosinophils (%)	0–1	0–1	0–1
Basophils (%)	0–5	0–1	0–1
H:L ratio	—	1.2–3.0	—
CHEMISTRIES			
AP (IU/L)	—	—	—
ALT (IU/L)	—	—	—
AST (IU/L)	150–388	150–275	141–369
Bile acid ($\mu\text{mol/L}$)	—	—	—
RIA	—	—	—
Colorimetric	15–96	—	20–97
Calcium (mg/dl)	—	7–13	8–12
Cholesterol (mg/dl)	—	—	100–257
CK (IU/L)	—	—	178–396
Chloride (mEq/L)	—	—	—
Creatinine (mg/dl)	0.1–0.4	—	—
GGT (IU/L)	—	—	—
Glucose (mg/dl)	200–350	200–325	200–400
LDH (IU/L)	150–450	—	124–302
Phosphorus (mg/dl)	—	—	—
Potassium (mEq/L)	—	—	—
Sodium (mEq/L)	—	—	—
Uric acid (mg/dl)	4–12	2.5–12.0	2.0–11.9
Protein, total (g/dl)	2.5–4.5	2.8–4.0	1.9–4.1
Albumin (g/dl)	—	—	1.3–2.1
Globulin (g/dl)	—	—	0.9–2.4
A:G ratio	—	—	1.0–2.3
Pre-albumin (g/dl)	—	—	—
α -globulin (g/dl)	—	—	—
β -globulin (g/dl)	—	—	—
γ -globulin (g/dl)	—	—	—

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Measurement	Lovebird ^{203,617,650}	Macaw ^{73,99,203}	Pionus Parrot ^{203,617}
HEMATOLOGY			
PCV (%)	44–57	47–55	35–54
RBC ($10^6/\mu\text{l}$)	3.0–5.1	2.7–4.5	2.4–4.0
Hb (g/dl)	13–18	15–17	11–16
MCV (fl)	90–190	125–170	85–210
MCH (pg)	27–59	36–55	26–54
MCHC (g/dl)	22–32	29–35	24–31
WBC ($10^3/\mu\text{l}$)	3–16	7–22	4.0–11.5
Heterophils (%)	40–75	40–60	50–75
Lymphocytes (%)	20–55	35–60	25–45
Monocytes (%)	0–2	1–8	0–2
Eosinophils (%)	0–1	0–1	0–2
Basophils (%)	0–6	0–1	0–1
H:L ratio	0.7–3.8	0.6–1.8	1.1–3.0
CHEMISTRIES			
AP (IU/L)	10–90	290–750	12–100
ALT (IU/L)	—	0–5	—
AST (IU/L)	100–360	90–180	135–365
Amylase (IU/L)	—	239–564	—
Bile acid ($\mu\text{mol/L}$)			
RIA	25–95	—	—
Colorimetric	12–90	7–100	15–92
Calcium (mg/dl)	9–15	9.5–10.5	7.0–13.5
Cholesterol (mg/dl)	95–335	100–300	130–295
CK (IU/L)	52–245	180–500	—
Chloride (mEq/L)	—	105–113	—
Creatinine (mg/dl)	0.1–0.4	0.5–0.6	0.1–0.4
GGT (IU/L)	2.5–18.0	0–4	—
Glucose (mg/dl)	200–400	280–320	125–300
LDH (IU/L)	100–350	40–250	—
Phosphorus (mg/dl)	3.2–4.9	4.6–6.4	2.9–6.6
Potassium (mEq/L)	2.5–3.5	2.2–3.9	3.5–4.6
Sodium (mEq/L)	137–150	148–156	145–155
Uric acid (mg/dl)	3–11	1–6	3.5–10.0
Protein, total (g/dl)	2.4–4.6	3.4–4.2	3.2–4.6
Albumin (g/dl)	—	1.3–1.7	—
Globulin (g/dl)	—	1.3–1.9	—
A:G ratio	0.8–2.0	0.7–1.0	0.6–1.9
Pre-albumin (g/dl)	—	0.3–0.6	—
α -globulin (g/dl)	—	0.1–0.4	—
β -globulin (g/dl)	—	0.2–0.6	—
γ -globulin (g/dl)	—	0.2–0.4	—

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Measurement	Quaker Parrot ^{203,213,617}	Senegal Parrot ^{203,617}
HEMATOLOGY		
PCV (%)	30–58	36–48
RBC ($10^6/\mu\text{l}$)	2.8–3.9	2.4–4.0
Hb (g/dl)	11–15	11–16
MCV (fl)	90–200	90–200
MCH (pg)	26–55	27–55
MCHC (g/dl)	22–32	23–32
WBC ($10^3/\mu\text{l}$)	8–17	4–14
Heterophils ($10^3/\mu\text{l}$)	0–24	55–75
Lymphocytes ($10^3/\mu\text{l}$)	74–90	25–45
Monocytes ($10^3/\mu\text{l}$)	1–4	0–2
Eosinophils ($10^3/\mu\text{l}$)	0–2	0–1
Basophils ($10^3/\mu\text{l}$)	0–6	0–1
H:L ratio	—	1.2–3.0
CHEMISTRIES		
AP (IU/L)	—	—
ALT (IU/L)	—	—
AST (IU/L)	150–380	120–330
Bile acid ($\mu\text{mol/L}$)		
RIA		20–85
Colorimetric	21–90	20–94
Calcium (mg/dl)	7–12	6.5–13.0
Cholesterol (mg/dl)	—	—
CK (IU/L)	—	100–330
Chloride (mEq/L)	—	—
Creatinine (mg/dl)	—	0.1–0.4
GGT (IU/L)	—	1–15
Glucose (mg/dl)	200–350	140–250
LDH (IU/L)	—	—
Phosphorus (mg/dl)	—	—
Potassium (mEq/L)	—	—
Sodium (mEq/L)	—	—
Uric acid (mg/dl)	3.5–11.5	2.3–10.0
Protein, total	3.8–5.0	3.0–4.5
Albumin (g/dl)	—	—
Globulin (g/dl)	—	—
A:G ratio	0.7–1.8	—
Pre-albumin (g/dl)	—	—
α -globulin (g/dl)	—	—
β -globulin (g/dl)	—	—
γ -globulin (g/dl)	—	—

a Hematologically, the psittacines are a very homogenous group, only small differences are appreciated between species.⁴⁷⁹

APPENDIX 17 Hematologic and serum biochemical values for juveniles of selected psittacines.

Measurement	Mean ± SD (range)				
	Cockatoos ⁹⁸ (9 species) (n = 152)	Umbrella Cockatoo ⁹⁸ (n = 111)	Macaws ⁹⁹ (7 species) (n = 113)	Blue and Gold Macaw ⁹⁹ (n = 43)	Eclectus Parrot ⁹⁷ (n = 111)
HEMATOLOGY					
PCV (%)	39.7 ± 9.0 (25–59)	39.3	41.7 ± 8.4 (25–55)	40 ± 7.7	43.8 ± 8.4 (26–58)
RBC (10 ⁶ /μl)	2.53 ± 0.63 (1.5–4.0)	2.54	2.9 ± 0.8 (1.5–4.5)	2.7 ± 0.7	2.69 ± 0.67 (1.5–4.0)
Hb (g/dl)	11.4 ± 2.9 (6.5–17.0)	11.6	12.3 ± 3.3 (7–17)	11.0 ± 2.9	12.5 ± 3.0 (6.5–18.0)
WBC (10 ³ /μl)	12.9 ± 6.3 (5.5–25.0)	16.6	19.2 ± 6.9 (7–30)	18.9 ± 5.6	13.7 ± 6.3 (5.5–25.0)
Heterophils (%)	50.8 ± 11.7 (27–74)	54.1	55.3 ± 10 (37–75)	52 ± 10	53.9 ± 11.4 (35–75)
Bands (%)	1.3 ± 2.3 (0–7)	1.31	0.6 ± 1.7 (0–5)	0.1 ± 0.7	0.5 ± 1.5 (0–5)
Lymphocytes (%)	41.2 ± 11.9 (17–65)	38.1	39 ± 10 (20–60)	42 ± 10	39.5 ± 11.5 (20–65)
Monocytes (%)	5.8 ± 3.4 (0–12)	5.35	4.4 ± 2.9 (1–10)	4.3 ± 2.7	5.0 ± 2.7 (1–11)
Eosinophils (%)	0	0.02	0 ± 0.2 (0–1)	0	0.1 ± 0.3 (0–1)
Basophils (%)	0.9 ± 1.1 (0–4)	1.03	0.5 ± 1.0 (0–3)	0.9 ± 1.3	1.1 ± 1.0 (0–3)
CHEMISTRIES					

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AP (IU/L)	579 ± 239 (200–1000)	440	970 ± 397 (290–1600)	1200 ± 390	489 ± 159 (200–900)	
ALT (IU/L)	2 ± 3 (0–13)	2.1	3 ± 2 (0–9)	4 ± 3	4 ± 3 (0–10)	
AST (IU/L)	143 ± 79 (50–400)	136	104 ± 31 (60–180)	101 ± 24	140 ± 58 (65–260)	
Calcium (mg/dl)	9.6 ± 0.7 (8–11)	9.8	9.9 ± 0.5 (8.5–10.8)	10.0 ± 0.5	9.3 ± 0.4 (8.5–10.2)	
Chloride (mEq/L)	110 ± 6 (97–120)	111	106 ± 6 (96–118)	104 ± 5	111 ± 5 (100–120)	
Cholesterol (mg/dl)	251 ± 105 (100–500)	291	165 ± 62 (75–300)	164 ± 67	268 ± 80 (125–450)	
CK (IU/L)	510 ± 235 (140–1000)	517	550 ± 312 (180–1100)	540 ± 267	616 ± 472 (200–1600)	
Creatinine (mg/dl)	0.4 ± 0.1 (0.2–0.7)	0.4	0.4 ± 0.1 (0.3–0.6)	0.4 ± 0.1	0.4 ± 0.1 (0.2–0.5)	270
GGT (IU/L)	2.6 ± 1.7 (0–6)	2.7	1.8 ± 1.2 (0–4)	1.7 ± 1.2	4 ± 2 (0–7)	271
Glucose (mg/dl)	253 ± 24 (200–300)	244	281 ± 30 (225–330)	288 ± 31	258 ± 18 (220–300)	
LDH (IU/L)	371 ± 285 (150–1000)	325	138 ± 84 (35–275)	144 ± 98	228 ± 101 (100–400)	
Phosphorus (mg/dl)	6.1 ± 1.1 (3.5–8.0)	5.6	6.5 ± 1.0 (4.6–6.9)	6.6 ± 0.9	6.8 ± 1.2 (4.5–9.0)	
Potassium (mEq/L)	3.6 ± 0.7 (2.5–5.5)	3.5	2.9 ± 0.8 (2.0–4.2)	2.7 ± 0.6	2.8 ± 0.7 (2.0–4.6)	
Protein, total (g/dl)	2.8 ± 0.7 (1.5–4.0)	3.0	2.6 ± 0.6 (1.5–3.5)	2.5 ± 0.7	2.9 ± 0.5 (1.8–3.8)	
Albumin (g/dl)	1.1 ± 0.3 (0.3–1.6)	1.7	1.2 ± 0.3 (0.6–1.7)	1.2 ± 0.3	1.3 ± 0.3 (0.8–1.8)	
Globulin (g/dl)	1.7 ± 0.5 (0.8–2.5)	0.9	1.3 ± 0.6 (0.8–1.9)	1.3 ± 0.6	1.5 ± 0.3 (0.8–2.2)	
A:G ratio	0.6 ± 0.2 (0.4–1.0)	0.6	0.8 ± 0.3 (0.5–1.0)	0.8 ± 0.2	0.9 ± 0.2 (0.6–1.1)	
Sodium (mEq/L)	145 ± 6 (135–155)	145	145 ± 6 (135–156)	142 ± 6	148 ± 6 (138–158)	
Urea (mg/dl)	2.0 ± 2.2 (0–6)	1.6	2.4 ± 2.3 (0–6)	1.9 ± 2.2	1.7 ± 2.4 (0–6)	
Uric acid (mg/dl)	2.9 ± 2.3 (0.2–8.5)	2.7	2.3 ± 2.1 (0.2–6.0)	1.9 ± 2.5	2.0 ± 1.6 (0.2–6.5)	
n, Number of blood samples (multiple blood samples were obtained from some individuals over time).						

APPENDIX 18 Hematologic and serum biochemical values of selected Passeriformes.

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Measurement	Canary ^{293,617}	Finch ³³⁸	Mynah ³³⁸
HEMATOLOGY			
PCV (%)	37–49	45–62	44–55
RBC ($10^6/\mu\text{l}$)	2.5–3.8	2.5–4.6	2.4–4.0
Hb (g/dl)	12–16	—	—
MCV (fl)	90–210	—	—
MCH (pg)	26–55	—	—
MCHC (g/dl)	22–32	—	—
WBC ($10^3/\mu\text{l}$)	4–9	3–8	6–11
Heterophils (%)	50–80	20–65	25–65
Lymphocytes (%)	20–45	20–65	20–60
Monocytes (%)	0–1	0–1	0–3
Eosinophils (%)	0–2	0–1	0–3
Basophils (%)	0–1	0–5	0–7
H:L ratio	—	0.3–3.3	0.4–3.3
CHEMISTRIES			
AP (IU/L)	20–135	—	—
ALT (IU/L)	—	—	—
AST (IU/L)	145–345	150–350	130–350
Bile acid ($\mu\text{mol/L}$)	—	—	—
RIA	23–90	—	—
Colorimetric	—	—	—
Calcium (mg/dl)	5.5–13.5	—	9–13
Cholesterol (mg/dl)	150–400	—	—
CK (IU/L)	55–350	—	—
Chloride (mEq/L)	—	—	—
Creatinine (mg/dl)	0.1–0.4	—	0.1–0.6
GGT (IU/L)	1–14	—	—
Glucose (mg/dl)	205–435	200–450	190–350
LDH (IU/L)	120–450	—	600–1000
Phosphorus (mg/dl)	2.9–4.9	—	—
Potassium (mEq/L)	2.2–4.5	—	0.3–5.1
Sodium (mEq/L)	135–165	—	136–152
Uric acid (mg/dl)	4–12	4–12	4–10
Protein, total (g/dl)	2.8–4.5	3–5	2.3–4.5
Albumin (g/dl)	—	—	—
Globulin (g/dl)	—	—	—
A:G ratio	—	—	—

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APPENDIX 19 Hematologic and serum biochemical values of selected Galliformes.

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Measurement	Chicken ²⁹³	Ringneck Pheasant ⁶⁶⁵	Turkey ²⁹³	Quail ²⁹³
HEMATOLOGY				
PCV (%)	23–55	—	30.4–45.6	30.0–45.1
RBC ($10^6/\mu\text{l}$)	1.3–4.5	1.2–3.5	1.74–3.70	4.0–5.2
Hb (g/dl)	7.0–18.6	8.0–11.2	8.8–13.4	10.7–14.3
MCV (fl)	100–139	—	112–168	60–100
MCH (pg)	25–48	—	32.0–49.3	23–35
MCHC (g/dl)	20–34	—	23.2–35.3	28.0–38.5
WBC ($10^3/\mu\text{l}$)	9–32	18–39	16.0–25.5	12.5–24.6
Heterophils (%)	15–50	12–30	29–52	25–50
Lymphocytes (%)	29–84	63–83	35–48	50–70
Monocytes (%)	0.05–7.0	2–9	3–10	0.5–3.8
Eosinophils (%)	0–16	0	0–5	0–15
Basophils (%)	0–8	0–3	1–9	0–1.5
H:L ratio	0.2–1.7	0.14–0.48	0.6–1.5	0.4–1.0
CHEMISTRIES				
Calcium (mg/dl)	13.2–23.7	—	11.7–38.7	—
Cholesterol (mg/dl)	86–211	—	81–129	—
Creatinine (mg/dl)	0.9–1.8	—	0.8–0.9	—
GGT (IU/L)	—	—	—	—
Glucose (mg/dl)	227–300	—	275–425	—
Phosphorus (mg/dl)	6.2–7.9	—	5.4–7.1	—
Potassium (mEq/L)	3.0–7.3	—	6.0–6.4	1.4
Sodium (mEq/L)	131–171	—	149–155	180
Uric acid (mg/dl)	2.5–8.1	—	3.4–5.2	—
Protein, total (g/dl)	3.3–5.5	—	4.9–7.6	3.4–3.6
Albumin (g/dl)	1.3–2.8	—	3.0–5.9	—
Globulin (g/dl)	1.5–4.1	—	1.7–1.9	—

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APPENDIX 20 Hematologic and serum biochemical values of selected Anseriformes (waterfowl) and Columbiformes.

Measurement	Canada Goose ²⁹³	Mallard Duck ⁶⁶⁵	Pigeon ^{293,371,539}
HEMATOLOGY			
PCV (%)	38–58	—	39.3–59.4
RBC ($10^6/\mu\text{l}$)	1.6–2.6	2.1–3.8	2.1–4.2
Hb (g/dl)	12.7–19.1	7.4–10.9	10.7–14.9
MCV (fl)	145–174	—	118–144
MCH (pg)	53.7–70.0	—	32–48
MCHC (g/dl)	28–29	—	20–30
WBC ($10^3/\mu\text{l}$)	13.0–18.5	24–40	10–30
Heterophils (%)	—	26–66	15–50
Lymphocytes (%)	—	33–63	25–70
Monocytes (%)	—	1–4	1–3
Eosinophils (%)	—	0	0–1.5
Basophils (%)	—	0–4	0–1
H:L ratio	0.5–0.9	0.4–2.0	0.21–2.00
CHEMISTRIES			
AP (IU/L)	72 ± 43	—	160–780
ALT (IU/L)	43 ± 11	—	19–48
AST (IU/L)	75 ± 17	—	45–123
Bile acid ($\mu\text{mol/L}$)			
RIA	—	—	22–60
Colorimetric	—	—	—
Calcium (mg/dl)	10.2 ± 0.7	—	7.6–10.4
Cholesterol (mg/dl)	172 ± 28	—	—
CK (IU/L)	—	—	110–480
Chloride (mEq/L)	105 ± 4	—	101–113
Creatinine (mg/dl)	0.8 ± 0.3	—	0.3–0.4
GGT (IU/L)	2 ± 3	—	0–2.9
Glucose (mg/dl)	210 ± 31	—	232–269
LDH (IU/L)	301 ± 80	—	30–205
Phosphorus (mg/dl)	2.8 ± 0.9	—	1.8–4.1
Potassium (mEq/L)	3.4 ± 0.6	—	3.9–4.7
Sodium (mEq/L)	142 ± 4	—	141–149
Uric acid (mg/dl)	8.3 ± 2.3	—	2.5–12.9
Protein, total (g/dl)	4.8 ± 0.7	—	2.1–3.3
Albumin (g/dl)	2.1 ± 0.2	—	1.5–2.1
Globulin (g/dl)	2.8 ± 0.6	—	0.6–1.2
A:G ratio	0.76 ± 0.13	—	1.5–3.6

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APPENDIX 21 Hematologic and serum biochemical values of selected Piciformes and ratites.

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Measurement	Toucan ^{338,617}	Emu ^{291,293,520,617}	Ostrich ^{293,350,617}
HEMATOLOGY			
PCV (%)	45–60	40–60	40–55
RBC ($10^6/\mu\text{l}$)	2.5–4.5	2.5–4.5	2.5–4.5
WBC ($10^3/\mu\text{l}$)	4–10	8–25	10–25
Heterophils (%)	35–65	45–75	55–90
Lymphocytes (%)	25–50	20–40	10–40
Monocytes (%)	—	0–2	0–2
Eosinophils (%)	0–4	0–1	0–1
Basophils (%)	0–5	0–1	0–1
CHEMISTRIES			
AP (IU/L)	—	—	130–220
AST (IU/L)	130–330	80–380	190–240
Bile acid ($\mu\text{mol/L}$)			
RIA	20–40	6–45	4–40
Colorimetric	—	—	—
Calcium (mg/dl)	10–15	8.8–12.5	13–20
Cholesterol (mg/dl)	—	68–170	80–170
CK (IU/L)	—	100–750	600–1200
Chloride (mEq/L)	—	—	20–60
Creatinine (mg/dl)	0.1–0.4	0.22	0–12
GGT (IU/L)	—	—	0–12
Glucose (mg/dl)	220–350	100–290	150–260
LDH (IU/L)	200–400	310–1200	225–1000
Phosphorus (mg/dl)	—	3.8–7.2	7.5–12.5
Potassium (mEq/L)	—	3.5–6.5	4.5–8.5
Sodium (mEq/L)	—	—	100–160
Uric acid (mg/dl)	4–14	4.5–14.0	6.5–14.5
Protein, total (g/dl)	3–5	3.4–5.6	2.0–5.5
Albumin (g/dl)	—	1.0–2.5	1.0–2.5

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APPENDIX 22 Hematologic and serum biochemical values of selected raptors.

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Measurement	Bald Eagle ¹²	Golden Eagle ²⁴⁶	Great Horned Owl ⁷⁵	Kestrel ⁴⁸⁵
HEMATOLOGY				
PCV (%)	—	35–47 (41)	30–47	—
RBC ($10^6/\mu\text{l}$)	—	1.9–2.7 (2.4)	—	—
Hb (g/dl)	—	12.1–15.2 (13.8)	—	—
WBC ($10^3/\mu\text{l}$)	—	11.7–14.7 (13.1)	14.5–32.5	14.5–57.0
Heterophils (%)	—	81–86	—	11–33
Lymphocytes (%)	—	14–22	—	24–58
Monocytes (%)	—	0	—	0.3–3.0
Eosinophils (%)	—	2–5	—	9–59
Basophils (%)	—	0–1	—	1.5–3.8
H:L ratio	—	—	—	0.2–1.4
CHEMISTRIES				
AP (IU/L)	23–30	—	21–108	—
ALT (IU/L)	—	—	0–59	—
AST (IU/L)	153–370	—	32–538	—
Calcium (mg/dl)	8.2–10.6	—	—	—
GGT (IU/L)	—	—	0–15	—
Glucose (mg/dl)	285–400	—	—	—
LDH (IU/L)	—	—	109–1320	—
Phosphorus (mg/dl)	2.4–4.3	—	—	—
Uric acid (mg/dl)	5.5–14.8	—	—	—
Protein, total (g/dl)	3.0–4.1	—	3.9–6.3	—

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Measurement	Peregrine Falcon ^{289,492}	Red-Tailed Hawk ^{12,75,293}	Sharp-Shinned Hawk ⁴⁸⁵
HEMATOLOGY			
PCV (%)	37–53	31–43	44–52
RBC ($10^6/\mu\text{l}$)	3–4	2.41–3.59	—
Hb (g/dl)	118–188	10.7–16.6	—
MCV (fl)	118–146	150–178	—
MCH (pg)	40.0–48.4	46.0–57.4	—
MCHC (g/dl)	319–352	297–345	—
WBC ($10^3/\mu\text{l}$)	3.3–11.0	19.1–33.4	7.7–16.8
Heterophils (%)	1–9	—	16–24
Lymphocytes (%)	1–3	—	54–75
Monocytes (%)	0.1–0.9	—	0–3
Eosinophils (%)	0–0.3	—	5–11
Basophils (%)	0–0.6	—	0–1
CHEMISTRIES			
AP (IU/L)	97–350	22–138	—
ALT (IU/L)	19–54	3–50	—
AST (IU/L)	20–52	76–492	—
Bile acid ($\mu\text{mol/L}$)	—	—	—
RIA	20–118	—	—
Calcium (mg/dl)	—	10.0–12.8	—
Cholesterol (mg/dl)	175–401	—	—
CK (IU/L)	357–850	—	—
Chloride (mEq/L)	121–134	118–129	—
GGT (IU/L)	0–7	0–20	—
Glucose (mg/dl)	11–16	292–390	—
LDH (IU/L)	625–1210	0–2640	—
Phosphorus (mg/dl)	—	1.9–4.0	—
Potassium (mEq/L)	1.6–3.2	2.6–4.3	—
Sodium (mEq/L)	152–168	143–162	—
Uric acid (mg/dl)	4.4–22.0	8.1–16.8	—
Protein, total (g/dl)	2.5–4.0	3.9–6.7	2.4–3.2
Albumin (g/dl)	0.8–1.3	—	—
Globulin (g/dl)	1.6–2.8	—	—
A:G ratio	0.4–0.6	—	—

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APPENDIX 23 Biologic and physiologic values of selected avian species.^{a,10,24,98,99,137,194,195,241,243,293,323,432,525,588,629}

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Species	Incubation Period (days) ^b	Fledgling Age (days)	Weaning Age (days)		Puberty	Lifespan in Captivity (maximum years)	Body Weight (g) ^c
			Parent-Raised	Hand-Reared			
PSITTACINES							
African grey parrot	26–28 ^d	50–65	100–120	75–90	4–6 yr	50–60	554 (370–534)
Amazon parrot	^e	45–60	90–120	75–90	4–6 yr	>50 (80)	^f
Australian parakeet	18–19	30–45	50–65	—	1–3 yr	10–12	30–110
Budgerigar parakeet	16–18	22–26	30–40	30	6–9 mo	5–10 (18)	30
Cockatiel	18–20	32–38	47–52	42–49	6–12 mo	10–12 (30)	80–90
Cockatoo, galah	22–24	45–55	90–120	80–90	1 yr	40–60	^g
Cockatoo, large	^h	60–80	120–150	95–120	5–6 yr	50–60	^g
Cockatoo, medium	^h	45–60	90–120	75–100	3–4 yr	40–60	^g
Conure	ⁱ	35–40	45–70	60	2–3 yr	25–40	80–100 ^j
Eclectus parrot	26–28	72–80	120–150	100–110	4 yr	20–40 (80)	432 (347–512)
Lories/lorikeets	21–27	42–50	62–70	50–60	2 yr	20–30	—
Lovebirds	18–24	30–35	45–55	40–45	6–12 mo	15–30	42–48
Macaw, small	23–26	45–60	90–120	75–90	4–6 yr	50–80	^k
Macaw, large	26–28	70–80	120–150	95–120	5–7 yr	75–100	^k
Ring-neck parakeet	22–23	40–45	55–65	—	3 yr	18–25	—
PASSERINES							
Zebra or society finch	12–16	18–22	25–28	—	9–10 mo	4–7	10–16
Canary	12–14	14	21	—	<1 yr	6–12	12–30
Mynah	14–15	30	60	—	2–3 yr	12	180–260
COLUMBIFORMES							
Pigeon	16–19	28–35	35	—	12 mo	4–8 (>20?)	240–300
Dove	12≥14	18	—	—	12 mo	4–8	240–300
GALLIFORMES							
Pheasant	22–24	—	Precocial	—	1 yr	10–18	—
RATITES							
Emu	50–57	—	Precocial	—	3–5 yr	30	55 kg
Ostrich	41–43	—	Precocial	—	4 yr	80	150–200 kg

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a Guidelines only. Data vary between references.

b *Brotheria* parakeets, 22; *Psittacula* parakeets, 23–26; Quaker parakeet, 23; Pionus parrot, 25–26; Senegal parrot, 24–25.

c Princess of Wales parakeet, 108 (102–129); kakariki parakeet, 56 (35–43); red-rumped parakeet, 65 (62–69); Bourke's parakeet, 40 (35–43).

d Congo, 28; Timneh, 26.

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- e Yellow-naped, yellow-fronted, yellow-crowned, double yellow-headed, 28–29; green-cheeked, blue-fronted, 26; spectacled (white-fronted), 24.
- f Blue-crowned, 740 (618–998); blue-fronted, 432 (361–485); Mexican red-headed, 360 (343–377); yellow-naped, 596 (476–795); double yellow-headed, 568 (463–694).
- g Bare-eyed, 331; greater sulphur-crested, 806; Leadbeater's (Major Mitchell's), 423 (381–474); lesser sulphur-crested, 303; Moluccan, 808; rose-breasted, 299; triton, 559; umbrella, 552.
- h Bare-eyed, 23–24; citron-crested, 25–26; greater sulphur-crested, 27–28; Leadbeater's, 26; lesser sulphur-crested, 24–25; Moluccan, 28–29; palm, 28–30; triton, 27–28; umbrella, 28.
- i Nanday, 21–23 (25); Patagonian, 24–25; sun, 27–28; blue-crowned, 23–24; orange-fronted, 30.
- j Queen of Bavaria, 262 (252–276).
- k Scarlet, 1103; blue and gold, 1021; green-winged, 1179; military, 788; hyacinth, 1355 (1197–1466); red-fronted, 458.

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APPENDIX 24 Biologic and physiologic values of selected Anseriformes (waterfowl) species. ¹⁹⁴

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Species	Weight (kg)		Sexual Maturity (yr)	Clutch Size	Incubation Period (days)	Longevity (yr)	Respiratory Rate (breaths/min)	Heart Rate (BPM)	Cloacal Temperature °F (°C)
	Male	Female							
Common eider	2.25	2.12	1	3–6	25–30	10–15	30–95	180–230	105.8 (41)
European goldeneye	0.99–1.16	0.7–0.8	1	9–11	27–32	10–15	30–95	180–230	105.8 (41)
European wigeon	0.7	0.64	1	7–11	23–25	10–15	30–95	180–230	105.8 (41)
Mallard	1.26	1.1	1	8–12	23–29	10–15	30–95	180–230	105.8 (41)
Mandarin duck	0.44–0.55	0.44–0.55	1	9–12	28–30	10–15	30–95	180–230	105.8 (41)
Muscovy duck	2–4	1.1–1.5	1	8–15	35	10–15	30–95	180–230	105.8 (41)
Tufted duck	1.1	1.05	1	6–14	23–25	10–15	30–95	180–230	105.8 (41)
Bar-headed goose	2–3	2–3	2	4–6	27	15–20	13–40	80–150	104.9 (40.5)
Hawaiian goose	2.2	1.9	2	3–5	29	15–20	13–40	80–150	104.9 (40.5)
Pink-footed goose	2.6	2.35	2	3–5	26–27	15–20	13–40	80–150	104.9 (40.5)
Red-breasted goose	1.3–1.6	1.15	2	3–7	23–25	15–20	13–40	80–150	104.9 (40.5)
Mute swan	12.2	8.9	5	4–8	35–40	25–30	13–40	80–150	104.9 (40.5)

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APPENDIX 25 Biologic and physiologic values of selected raptors. ^{43,86}

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Species	Longevity (yr)	Minimum Breeding Age (yr)	Clutch Size	Incubation Period (days)	Interval Between Eggs (days)	Start of Incubation
Barn owl	—	1	4–7	30–31	2–3	First egg
Common kestrel	—	1	3–6	27–29	1–2	Second to third egg
Eurasian buzzard	—	2–3	2–4	36–38	3	First to second egg
Golden eagle	50–60	>5	1–3	43–45	—	—
Harris hawk	20–30	>3	2–5	32	2–3	Penultimate or last egg
Merlin	10–14	2	2–7	28–32	—	—
Northern eagle owl	50–60	2–3	2–4	34–36	2–3	First to second egg
Northern goshawk	15–20	>3	3–5	35–38	2–3	First to second egg
Northern sparrow hawk	—	1–2	4–6	35	2–3	Third to fourth egg
Peregrine falcon	15–20	>3	3–4	29–32	2–3	Penultimate or last egg
Snowy owl	—	2	3–9	30–33	2–3	First egg

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APPENDIX 26 Quick reference to abnormalities of the standard avian hematology profile. [204,483](#)

Parameter	Increases	Decreases
PCV/RBC	Dehydration Increased oxygen demand • Chronic obstructive pulmonary disease • Obstructive airway disease • Chronic respiratory disease	Blood loss • Parasitism • Coagulopathies • Gastrointestinal bleeding • Destruction • Hematozoan parasites • Bacterial septicemia • Aflatoxicosis • Chronic inflammatory disease • Mycobacteriosis, chlamydiosis, aspergillosis, chronic hepatitis • Neoplasia • Lymphoid leukemia
Heterophils	Inflammatory processes • Bacterial (including <i>Mycobacterium</i>) and fungal infections • Excess corticosteroids • Endogenous production • Exogenous administration Birds with a high heterophil/lymphocyte ratio may mount a greater leukocytic response	Infection • Bacterial and viral (e.g., PBFD) Poor sample preparation, collection, storage
Lymphocytes	Chronic antigenic stimulation • Chronic infections Lymphocytic leukemia Increased excitability	Excess corticosteroids • Endogenous release • Exogenous administration Severe viral infection Endotoxemia Septicemia Immunosuppressive drugs

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Monocytes	Chlamydiosis	Acute infection	
	Bacterial infections (including <i>Mycobacterium</i>)	Inflammation	
	Mycotic granulomatous diseases		
	Tissue necrosis		
Eosinophils	Parasitism		
	Gastrointestinal parasitism	Corticosteroids	
Basophils	Delayed type IV hypersensitivity reactions	Physiologic stress	
	Early inflammatory responses associated with histamine release	—	
	Anaphylactic reaction		
	Induced molting		
	Severe and prolonged stress		282
Hemostasis	—	Vitamin K deficiency	283
		Rodenticide toxicity	
		Aflatoxicosis	
		Circovirus-associated thrombocytopenia	
		Conure bleeding syndrome	
		Septicemia-associated DIC (as with polyomavirus and reovirus)	
		Hepatic disease or failure	283

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APPENDIX 27 Quick reference to abnormalities of the standard avian biochemical profile. [a,202,241,301,373](#)

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Chemistry	Increases		Decreases	
	Nonmedical	Medical	Nonmedical	Medical
Alkaline phosphatase (IU/L)	Juveniles have higher levels	Hyperparathyroidism induced osteoclastic activity (fractures); egg laying; hepatic disease; enteritis; aflatoxicosis	—	Dietary zinc deficiency
ALT (IU/L)	Seasonal variation in raptors; sample hemolysis	—	Seasonal variation in raptors	—
Amylase (IU/L)	—	Pancreatitis; gastrointestinal disease; zinc toxicity	—	—
AST (IU/L)	Rare; severe lipemia; 300–1000	Liver, muscle, or heart damage; vitamin E/selenium, methionine deficiency; 300–15,000	—	<50; end-stage liver disease
Bile acids (μmol/L)	Lipemia; sample hemolysis; such samples should not be analyzed	Loss of liver function, even with normal enzymes	Lipemic samples that are chemically treated	Response to therapy; liver cirrhosis; microhepatica
Calcium (mg/dl)	Lipemia (or cloudy from other causes); protein elevations; bacterial contamination	Hormonal disorders; egg production; metabolic disease; excess dietary vitamin D; dehydration; osteolytic neoplasia	EDTA; bacterial contamination; young birds have lower levels	<8; metabolic and nutritional disorders; lead poisoning; glucocorticoid administration; low albumin; African grey parrot hypocalcemia
Cholesterol (mg/dl)	Postprandial ⁵³⁸ ; high fat diet; carnivorous diet	Metabolic disease; hepatic lipidosis; bile duct obstruction; hypothyroidism; starvation	—	Liver, metabolic disease
Creatine phosphokinase (IU/L)	>300; healthy birds up to 1000	600–25,000; muscle or heart damage; CNS disease (seizures); vitamin E/selenium deficiency; chlamydiosis; lead toxicity; IM injections	<10; bacterial contamination	Rare
Creatinine (mg/dl)	—	Not useful in birds	—	Not useful in birds
Glucose (mg/dl)	Improper dilution; postprandial; posthandling	Stress, 400–600; diabetes, 800–1500; corticosteroids	<100; unseparated blood; bacterial contamination	<100; hepatic dysfunction; septicemia; neoplasia; aspergillosis
Lactate dehydrogenase (IU/L)	Sample hemolysis	300–15,000; liver, heart, or muscle damage; hepatitis; muscle damage	<50	End-stage liver disease
Lipase (IU/L)	—	Acute pancreatitis	—	—

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Phosphorus (mg/dl)	Postprandial; sample hemolysis	Severe renal disease; nutritional secondary hyperparathyroidism; hypoparathyroidism	EDTA	Hypovitaminosis D; malabsorption; chronic glucocorticoid therapy	285
Potassium (mEq/L)	Hemolysis; dietary supplementation	Adrenal disease; metabolic disease; severe tissue damage; renal disease; acidosis; dehydration; hemolytic anemia	—	Adrenal disease; metabolic disease; diuretic therapy; alkalosis; overhydration; dietary deficiency	286
Protein, total (g/dl)	Lipemia; non-temperature-compensated refractometer	Inflammation; dehydration; chronic infection; gamma globulinopathy; lymphoproliferative disease; myelosis	Non-temperature-compensated refractometer	Chronic hepatopathy; malabsorption; renal disease; blood loss; neoplasia; starvation/Malnutrition	
Sorbitol dehydrogenase (IU/L)	—	Hepatitis	—	—	
Sodium (mEq/L)	Dietary supplementation	Dehydration; salt poisoning	—	Renal disease; overhydration	
Uric acid (mg/dl)	5–15; severe lipemia; dirty nail clip; carnivorous birds have higher levels	Renal disease; gout; dehydration; postprandial; ovulation; tissue damage; starvation; hypervitaminosis D	Overhydration of patient; juvenile levels are lower	End-stage liver disease	
<p>a The ranges given are not absolute and are to be used as a guide for interpretation of a wide range of avian species.</p>					

APPENDIX 28 Approximate resting respiratory rates of selected avian species and by weight. ^{107,194,541}

Species	Respiratory Rate (breaths/min) ^a
Finch	90–110
Canary	60–80
Budgerigar	60–75
Lovebird	50–60
Cockatiel	40–50
Small conure	40–50
Large conure	30–45
Toucan	15–45
Amazon parrot	15–45
Cockatoo	15–40
Macaw	20–25
Raptor	10–20

Weight (g)	Respiratory Rate (breaths/min) ^a
100	40–52
200	35–50
300	30–45
400	25–30
500	20–30
1000	15–20

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a Restraint can increase respiratory rate 1.5–2× resting rate.

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APPENDIX 29 T₄ values of selected avian species.^{a,293,365,371,617,659}

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Species	Baseline T ₄ (nmol/L) ^b	Post-TSH (nmol/L) ^{c,d}
African grey parrot	3.83–27.03 ^{293,617}	—
	1.83 ± 0.57 ³⁶⁵	11.97 ± 3.73 ³⁶⁵
	≤1.93 ⁶⁵⁹	23.04 ± 13.26 ⁶⁵⁹
Amazon parrot	1.29–14.16 ^{293,617}	—
	10.54 ± 8.88 ³⁶⁵	35.26 ± 20.50 ³⁶⁵
	5.53 ± 0.36 (red-lored) ⁶⁵⁹	78.64 ± 44.79 ⁶⁵⁹
	≤1.93 (blue-fronted) ⁶⁵⁹	98.33 ± 26.38 ⁶⁵⁹
Budgerigar	6.44–27.03 ^{293,617}	—
Canary	9.01–41.18 ^{293,617}	—
Cockatiel	9.01–30.89 ^{293,617}	—
	15.24 ± 8.70 ³⁶⁵	50.19 ± 7.28 ³⁶⁵
Cockatoo	17.54 ± 8.40 ³⁶⁵	45.17 ± 16.94 ³⁶⁵
Conure	6.44–25.74 ^{293,617}	—
	2.27 ± 0.99 ³⁶⁵	17.37 ± 9.92 ³⁶⁵
Lovebird	2.57–55.34 ^{293,617}	—
Macaw, blue and gold	4.39 ± 2.29 ³⁶⁵	15.91 ± 8.16 ³⁶⁵
Macaw, scarlet	1.72 ± 0.66 ³⁶⁵	8.31 ± 3.99 ³⁶⁵
Pigeon	6.05–35.01 ^{293,371,617}	—

a 0.5 µg/dl = 6.5 nmol/L = 5.0 ng/ml²¹⁹ To convert thyroxine from µg/dl to nmol/L multiply by 12.87.³⁷¹

b T₄ levels will vary with the time of day and year with higher levels measured in the winter. Physiologic states such as molting or reproductive activity may also alter the ratio of T₄ to T₃ released. The half-life of thyroid hormones is much shorter in birds than in mammals, therefore it is difficult to accurately measure single hormone levels.⁴⁰⁶

c The canine radioimmunoassay kit does not accurately measure total T₄ below 6.5 nmol/L.²¹⁹ Results of high sensitivity total T₄ testing in parrots ranged from 2.0–6.0 nmol/L. This high sensitivity test is available through the University of Tennessee Clinical Endocrinology Laboratory (865–974–5638).²¹⁸

d Low-dose TSH (0.2 IU/kg).

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APPENDIX 30 Urinalysis values in psittacines. ^{62,206,469}

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Measurement	Normal Values	Comments
Specific gravity (g/ml)	1.005–1.020	—
pH	6.5–8.0	Laying hens and carnivorous birds may have more acidic urine; cloacal contents may alter urine pH
Protein	Negative to trace	—
Glucose	Negative to trace	—
Ketones	Negative	Ketonuria is sometimes present in migratory birds
Bilirubin	Negative	—
Urobilinogen	Negative	—

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APPENDIX 31 Aplplanation tonometry data for selected raptors. ⁵⁸⁵

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Species (n)	Intraocular Pressure (mm Hg)
Red-tailed hawk (10)	20.6 (±3.4)
Swainson's hawk (6)	20.8 (±2.3)
Golden eagle (7)	21.5 (±3.0)
Bald eagle (3)	20.6 (±2.0)
Great horned owl (6)	10.8 (±3.6)

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4.1 APPENDIX 32 Checklist of supportive care procedures used in companion bird medicine.

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Because it is frequently difficult to establish an accurate diagnosis, supportive care is an essential component of companion bird medicine. Supportive care includes:

1. Minimal handling and other stressors
2. Hospitalization
 - place patient in a warm, quiet, well-ventilated environment with minimal to no disturbance
 - supplemental heat (30° C–32° C; 85° F–90° F)
 - debilitated birds are often hypothermic
3. Fluid therapy (see [Appendixes 33](#) and [34](#))
4. Corticosteroids (use with caution because of immunosuppressive effects, etc.) in cases of:
 - shock and poor vascular perfusion
 - extreme stress
 - CNS trauma
 - selected toxemias and intoxications
5. Vitamin therapy

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- multiple vitamins (including vitamin A) as needed
- B complex in selected cases of injury, anorexia, cachexia, CNS disorders, or blood loss

6. Antibiotics (see [Table 19](#))

- to control primary infections and for injured or debilitated birds in which secondary infections may result

7. Iron dextran

- iron deficiency or after hemorrhage

8. Normal photoperiod (or subdued lighting if needed)

9. Oxygen

- dyspnea, hypoxia, or severe pneumonia and airsacculitis

10. Maintaining body weight

- weigh daily if possible
- offer favorite foods and avoid changing diet while ill

11. Gavage (see [Appendixes 34–37](#))

- malnourishment, anorexia, cachexia, and dehydration
- high carbohydrate formula is initially recommended
- high-protein/high-calorie formulas may be used to increase body weight during recovery

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4.2 APPENDIX 33 Fluid therapy recommendations for birds.

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When evaluating a patient for fluid therapy, the following factors should ideally be considered: hydration status, electrolyte balance, acid-base status, hematologic and biochemical values, and caloric balance.

- Warm fluids to 100° F–102° F (38° C–39° C) to help prevent or correct hypothermia.
- Use caution when giving dextrose parenterally; 5% dextrose is a good choice for simple dehydration. However, it can exacerbate problems significantly if used concurrently with significant electrolyte loss.^{393,581}
- When given orally, dextrose is rapidly absorbed from the intestinal tract without creating an influx of fluid into the intestinal lumen and secondary dehydration.^{393,581}
- Potassium chloride can be diluted in fluids to correct for potassium depletion based on electrolyte analysis (0.1–0.3 mEq/kg).⁶¹¹

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- Hetastarch at 10-15 ml/kg IV q8h for up to 4 treatments or dextrans may be effective for hypoproteinemia. Synthetic colloids should be used with caution in patients with congestive heart failure or renal failure.^{418,587}

Total parenteral nutrition may also be considered.^{127,128}

Maintenance and deficit replacement^{270,418,491,542,570}:

- Determine fluid deficit.

Fluid deficit (ml) = body weight (g) × % dehydration

- Determine daily maintenance.

Daily maintenance is estimated at 50 ml (range, 40-60 ml/kg/day) in many avian species. (The smallest passerines drink 250–300 ml/kg daily.³⁸³)

- If possible, replace 50% of the deficit in the first 12–24 hr and the remainder over the next 24-48 hr. Some clinicians recommend replacing 20%-25% of the deficit in the first 4–6 hr and the remaining volume during the next 24–72 hr.

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APPENDIX 34 Routes of administration and maximum suggested volumes of fluids that can be administered to psittacines.^{240,506,581}

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Route	Maximum Suggested Volume of Fluid ^a
Gavage	Administer up to 5 ml/100 g per bird ^b Initial volume should be much less in critically ill and anorectic patients (begin with ½ to ⅓ of estimated crop volume) Crop volume may be up to 10% BW in neonatal birds
IV or IO bolus	Administer up to 10 ml/kg (ideally over a 5–10 min period)
Subcutaneous	50 ml/kg ^{c,d}

a Combinations of routes (PO, SC, and IO/IV) are recommended if large fluid volumes are administered.

b Crop volume may be estimated at 5% BW.

c Volumes of 10–15 ml/kg may be comfortably given per subcutaneous injection site, although up to 25 ml/kg per site may be given. Overdistension of the area may compromise blood supply to the area and reduce absorption.⁵⁸¹

d Hyaluronidase (Wydase, Wyeth-Ayerst) (1 ml [150 IU]/L fluids) may be used in most species to increase the absorption rate of fluids.³⁰³

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APPENDIX 35 Suggested initial to maximum volumes and frequency of gavage feeding in anorectic birds.^{491,541}

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Species	Volume (ml) ^{a,b}	Frequency ^a
Finch	0.1–0.5	q4h
Budgerigar	0.5–3.0	q6h
Lovebird	1–3	q6h
Cockatiel	1–8	q6h
Small conure	3–12	q6h
Large conure	7–24	q6–8h
Amazon parrot	5–35	q8h
Cockatoo	10–40	q8–12h
Macaw	20–60	q8–12h

a Adjust volume and frequency as crop accommodates larger volumes.

b Generally 3%–5% of body weight.²³⁹

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APPENDIX 36 Suggested feeding requirements of a bird in relation to its body weight.⁵⁰⁸

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Body Weight (g)	Percentage of Body Weight Required Daily
100–200	18–25
201–800	11–19
801–1200	7–11
4,000–10,000	3.5–6.0

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4.3 APPENDIX 37 Calculation of enteral feeding requirements for birds.

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Please see [Appendix 107](#) regarding calculation of basal metabolic rate (BMR) and maintenance energy requirement (MER). Caloric values for the three food types are:

Protein	4.29 kcal/g
Carbohydrate	4.09 kcal/g
Fat	9.29 kcal/g

Animals are unable to fully use all the calories in these nutrients, but efficiency is estimated between 80%–90% depending on the type of nutrition. Commercial enteral solutions are estimated to have a digestibility of 95%. Some commercially available enteral products are listed below. Each product has varying levels of protein, carbohydrate, fat, and water. Other food sources can be used as long as nutrient levels and digestibility can be determined. Following is an example of a calculation of nutrient requirements based on BMR.

Example: A 250-g lilac-crowned Amazon parrot is debilitated and not eating because of a bacterial infection.

$$\text{BMR (kcal/day)} = \kappa W^{0.75}$$

$$\text{MER (kcal/day)} = (1.5 \times \text{BMR})$$

κ = kcal/kg/day constant

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(nonpasserines, 78; passerines, 129)

- First calculate MER:

$$\text{MER} = (1.5)(78 \text{ kcal/kg/day})(0.250 \text{ kg})^{0.75} = 41.4 \text{ kcal/day}$$

- An adjustment for sepsis is made by multiplying by 1.5 (see [Appendix 107](#)):

$$\text{Sepsis} = 1.5 \times \text{MER} = (1.5)(41.4 \text{ kcal/day}) = 62.1 \text{ kcal/day}$$

- Isocal HCN (2 kcal/ml) is selected as the nutrient source:

$$\text{Volume of Isocal} = (62.1 \text{ kcal/day}) / (2 \text{ kcal/ml}) = 31 \text{ ml/day}$$

- The average Amazon parrot can be gavaged 2.5% of its body weight:

$$\text{Volume that can be gavaged} = (0.025)(250 \text{ g}) = 6.25 \text{ ml}$$

- Therefore, 31 ml/day of Isocal HCN can be administered by gavage feedings of 6.25 ml q5h. However, this volume may need to be reduced initially depending on the bird's degree of debilitation.
- Refer to [Appendixes 34–36](#) for suggested volumes and frequency of gavage feeding in anorectic birds.

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- Nutrient values for selected nutritional products^{324,486}

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PRODUCT	PROTEIN (g) ^a	FAT (g) ^a	CARBOHYDRATES (g) ^a	WATER (ml/dl)	kcal/ml
Isocal (Mead Johnson)	3.4	4.4	13.3	84	1.0
Traumacal (Mead Johnson)	5.5	4.5	9.5	52	1.5
Pulmocare (Ross)	4.2	6.1	7.0	52	1.5
Isocal HCN (Mead Johnson)	3.8	5.1	10.0	35.5	2.0
Nutri-Support (Lafeber) 45 g + 45 ml water = 100 ml	10.8	2.25	28.1	45	1.53

	PROTEIN (%)	FAT (%)	FIBER (%)	MOISTURE (%)	
a/d (Hill's Prescription Diet)	8.5	6.6	0.5	78	1.3
CliniCare Canine/Feline Liquid Diet (Abbott)	8.2	5.1	—	81	0.92
Emeraid Critical Care (Lafeber's)	20	9.5	0.5	9	—
Exact Baby Bird Hand Feeding Formula (Kaytee)	22	9	5	10	3.89
Exact Macaw Hand Feeding Formula (Kaytee)	19	13	5	—	4.09
Maximum-Calorie Nutritional Stress/Weight Gain Formula	14	12	11	66	2.1

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a Nutrients per 100 kcal energy.

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4.4 APPENDIX 38 Doxycycline recipes commonly used in psittiacines. ^{176,484}

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Medicated water for cockatiels:

1. Mix doxycycline with tap water to a final concentration of 280 mg/L (0.28 mg/ml) with a magnetic stir bar and plate.
2. Prepare daily for 45 days.
3. No calcium supplementation should be provided.

Medicated seed for cockatiels:

1. Combine 60% hulled millet and 40% hulled sunflower seed with 6.25 ml sunflower oil/kg seed. Mix well.
2. Mix doxycycline with seeds at 500 mg/kg wet weight with an electric mixer.
3. Prepare daily for 45 days.
4. No calcium supplements should be provided.

Medicated seed for budgerigar parakeets:

1. Create a 1:4 mixture of hulled oat groat and hulled millet.
2. Mix well.
3. Add approximately 6 ml sunflower oil/kg seed (enough to coat seeds, but not dripping).
4. Mix well.
5. Add the contents of doxycycline hyclate capsules aseptically (300 mg drug/1 kg seed).
6. Prepare daily for 45 days.
7. No calcium supplements should be provided.

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4.5 APPENDIX 39 Selected sources of formulated and medicated diets for companion and aviary birds.

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Harrison's Bird Diets International^a

7108 Crossroads Blvd., Suite 325

Brentwood, TN 37027

Exotic Animal Formulary, 3rd Edition

Orders: (800) 346-0269

Support: (800) 745-7329

Fax: (800) 279-5984

Kaytee Products, Inc.

521 Clay St.

P.O. Box 230

Chilton, WI 53014

(414) 849-2321

(800) 669-9580

LaFeber Co^a

24981 N 1400 East Rd.

Cornell, IL 61319

(815) 358-2301

(800) 842-6445

Lakes Unlimited, Inc.^a

639 Stryker Ave.

St Paul, MN 55107

(612) 290-0606

(800) 634-2473

L'Avian Pet Products

Highway 75 South

Stephen, MN 56757

(800) 543-3308

Marion Zoological Scenic Birdfoods

Exotic Animal Formulary, 3rd Edition

13803 Industrial Park Blvd.

Plymouth, MN 55441

(612) 559-3305

(800) 327-7974

PMI Nutrition International

Mazuri Diets

1401 S. Hanley Rd.

St. Louis, MO 63144

(314) 768-4100

(800) 227-8941

Premium Nutritional Products

ZuPreem Diets

P.O. Box 2094

Mission, KS 66202

(913) 722-6336

(800) 345-4767

Pretty Bird International, Inc.^a

P.O. Box 177

5810 Stacy Trail

Stacy, MN 55079

(651) 462-1799

(800) 356-5020

Rolf C. Hagen Corp.

50 Hampden Rd.

Exotic Animal Formulary, 3rd Edition

Mansfield, MA 02048

(508) 339-9531

(800) 225-2700

Roudybush Foods^a

3550 Watt Ave., Suite 8

Sacramento, CA 95821

(888) 304-2473

Zeigler Brothers, Inc.^a

P.O. Box 95

Gardners, PA 17324

(717) 677-6181

(800) 841-6800

^a Source of medicated feeds.

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4.6 APPENDIX 40 Selected nutritional recommendations for waterfowl, raptors, and hummingbirds.

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4.6.1 WATERFOWL

Geese are browsers; domestic ducks feed on mixed grains and forage. Avoid grains in goslings for the first 4 wk of life. Grit and oyster should be fed *ad libitum*. Piscivorous birds require higher protein and can be offered trout chow and fish.

- Starter rations (< wk of age): 19%–22% protein³³⁶
- Grower rations: 12%–17%,³³⁶ reduce protein to 14% if angel wing is present in goslings
- Breeder rations: 17%–18% protein, 1–2 wk before laying³³⁶

4.6.2 RAPTORS (FOR DEBILITATED BIRDS)³⁰¹

- Rehydrate: see [Appendixes 33](#) and [34](#) (fluid therapy)
- Oral supplementation (Ultracal, Meade Johnson) (55 ml/kg/day)

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4.6.3

HUMMINGBIRD DIET⁶³⁸

- Ground whole quail (less feet, feathers, gastrointestinal tract)
- Small amounts of quail breast meat soaked with oral electrolytes
- Whole prey after establishing normal gastrointestinal time
- Stomach capacity is approximately 40 ml/kg⁵⁰⁸

180 ml 24% sugar water

1 tsp (4 g) Vital High Nitrogen (Ross Laboratories)

1/8 tsp Superpreen vitamins (RHB Laboratories)

1/8 tsp Nekton Tonic-I (Nekton)

In captivity, sugar water alone is not sufficient to sustain hummingbirds:

- Insects (e.g., *Drosophila* fruit fly) may be released into the enclosure.⁴⁵⁶
- Human protein dietary supplement may also be provided (1 envelope of Gevral Protein [Ledderly Labs]/5 L sugar solution) or ensure that commercial products contain adequate protein.

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4.7

APPENDIX 41 Management of egg retention in birds.^{41,43,58,356,418}

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Definitions

- Dystocia—obstruction of the oviduct by the developing egg
- Egg binding—delay in rate of passage of an egg through the oviduct

Etiology—often multifactorial

- Hypocalcemia
- Inadequate nutrition
- Abnormal egg shape or position
- Abnormally large egg
- Inadequately or soft-shelled egg
- Pelvic injury/fracture

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- Salpingitis
- Systemic/metabolic disease
- Oviduct scarring from previous dystocia or surgery
- Infection
- Neoplasia

Diagnosis

- History/clinical signs
- Physical examination
- Radiography
- Ultrasonography

Treatment

- Stabilize the patient
 - Administer warmed fluids SC, IV, or IO
 - Dextrose: 50% bolus IV or IO; 2.5% in fluids SC
 - Warm, dark, humidified environment
 - Nutritional support required in most cases
 - Calcium gluconate: 50-100 mg/kg IM or IV (slow)
 - Vitamin D₃: 10,000 IU vitamin A and 1,000 IU vitamin D₃/300 g body weight (Vital E-A+D, Schering)
- Medical management
 - Oxytocin: 5 IU/kg IM, may repeat q30min
 - Prostaglandin E₂: 0.1 ml/100 g intracloacal on uterine sphincter
 - Arginine vasotocin: not commercially available
- Surgical management
 - Attempt after 12–24 hr of medical management unless patient is obstructed
 - General anesthesia must be used

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<ul style="list-style-type: none">• Use caution when manipulating egg; do not press cranially when stabilizing the egg because this will compromise respiration• Manual expression<ul style="list-style-type: none">• gentle digital pressure to direct egg caudally• attempt alternate method if oviduct begins to prolapse• Cloacal ovocentesis<ul style="list-style-type: none">• 18-gauge needle regardless of size of patient• visualize egg/oviductal opening using a lubricated speculum or cotton applicators and focal light source• insert syringe into egg and aspirate contents while manually stabilizing egg• gently implode egg with digital pressure• extract fragments with curved hemostats	301
<ul style="list-style-type: none">• Percutaneous ovocentesis<ul style="list-style-type: none">• 18-gauge needle• stabilize egg against left side of body• surgically prepare area• insert needle and aspirate contents• gently implode egg with digital pressure• maintain hydration to promote passage of egg shell fragments• Salpingohysterectomy or salpingotomy	302

APPENDIX 42 Protocols used in treating mycobacteriosis in birds.^a

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Drug Combinations and Dosages										
Agent	1 ^{b,619}	2 ³⁸	3 ⁶¹⁹	4 ⁶¹⁹	5 ⁶¹⁹	6 ^{c,44}	7 ³⁴⁷	8 ¹⁴⁴	9 ⁶²⁰	10 ⁵⁴¹
Azithromycin	—	—	—	—	—	—	—	45 mg/kg PO q24h	—	43 mg/kg PO q24h
Ciprofloxacin	—	—	—	—	80 mg/kg PO q24h	—	—	—	—	15 mg/kg PO q12h ^d
Clarithromycin	—	—	—	—	—	—	55 mg/kg PO q24h	85 mg/kg PO q24h	—	—
Clofazimine	—	—	—	—	—	1.5 mg/kg PO q24h	—	—	6 mg/kg PO q24h	—
Cycloserine	—	—	—	—	—	5 mg/kg PO q12h	—	—	—	—
Enrofloxacin	—	—	30 mg/kg PO 24h	30 mg/kg PO q24h	—	10–15 mg/kg PO,IM q12h	6 mg/kg PO q24h	—	—	—
Ethambutol	30 mg/kg PO q24h	10 mg/kg PO q12h	30 mg/kg PO q24h	30 mg/kg PO q24h	30 mg/kg PO q24h	20 mg/kg PO q24h	30 mg/kg PO q24h	15–30 mg/kg PO q12–24h	30 mg/kg PO q24h	30 mg/kg PO q24h
Isoniazid	30 mg/kg PO q24h	—	—	—	—	—	—	—	—	—
Rifabutin	—	—	15 mg/kg PO q24h	—	—	—	45 mg/kg PO q24h	15–45 mg/kg PO q24h	—	15 mg/kg PO q24h
Rifampin	45 mg/kg PO q24h	15 mg/kg PO q12h	—	45 mg/kg PO q24h	45 mg/kg PO q24h	—	—	—	45 mg/kg PO q24h	—
Streptomycin	—	30 mg/kg IM q12h	—	—	—	—	—	—	—	—

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a Because of its zoonotic potential, controversy exists on whether to treat pet and aviary birds for *Mycobacterium avium*. Because *M. avium* isolates from birds differ from human isolates in antibiotic susceptibility, serovars, and genetic sequencing, pet birds are an unlikely source of *M. avium* in people (except immunosuppressed individuals). Nevertheless, veterinarians who treat birds with this disease do so at their own risk. The veterinarian should be aware that treatment is often lifelong for the bird, and that treatment does not necessarily prevent shedding.^{38,44,144,347,541,619}

b Mix into dextrose powder, mixed with a small amount of food.

c Recommended for use in raptors.

d Enrofloxacin (15 mg/kg PO q12), clofazimine (6 mg/kg PO q12h), or amikacin IM, IV can be used in lieu of ciprofloxacin with ethambutol, rifabutin, and azithromycin.

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4.8 APPENDIX 43 Suggested protocols for treating lymphosarcoma, lymphocytic leukemia, and osteosarcoma in birds.

4.8.1 C.O.P. PROTOCOL FOR LYMPHOSARCOMA¹⁹⁹

- Prednisone 25 mg/m² PO q24h
- Cyclophosphamide 200/m² IO q7d
- Vincristine 0.75 mg/m² IO q7d × 3 treatments
- Doxorubicin 30 mg/m² IO q21d
- L-asparaginase 400 IU/kg IM q7d
- Interferon α 15,000 IU/m² SC q2d × 3 treatments
- Diphenhydramine 2 mg/kg IO before doxorubicin and L-asparaginase treatments
- Dexamethasone 1 mg/kg IM before doxorubicin and L-asparaginase treatments

4.8.2 PROTOCOL FOR LYMPHOCYTIC LEUKEMIA OR LYMPHOSARCOMA^{a,439}

- Vincristine sulfate 0.5 mg/m² IV initial dose, then 0.75 mg/m² q7d × 3 treatments
- Prednisone 1 mg/454 g PO q12h
- Chlorambucil 1 mg/bird PO 2×/wk

4.8.3 PROTOCOL FOR CUTANEOUS LYMPHOSARCOMA^{b523}

- Vincristine 0.1 mg/kg IV q7-14d
- Chlorambucil 2 mg/kg PO 2×/wk

4.8.4 PROTOCOL FOR OSTEOSARCOMA¹³⁹

- Diphenhydramine 30 min before doxorubicin treatment (route not given)
- Doxorubicin 60 mg/m² is diluted in 6 ml sterile saline and administered IV over 30 min in an anesthetized patient via an angiocatheter in the jugular vein q30d
- Do not extravasate doxorubicin; doxorubicin may cause myelosuppression and cardiac toxicity; monitor the CBC
- Electrocardiography during treatment is recommended

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a Dosages are for a Pekin duck (*Anas platyrhynchos domesticus*).

b Procedure was developed for a blue-fronted Amazon parrot (*Amazona aestiva*).

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APPENDIX 44 Cardiopulmonary resuscitation in birds.^a

Emergency Drug	Dose	15 g (Canary; Finch)	30 g (Budgerigar)	40–50 g (Lovebird)	100 g (Conure; Cockatiel)	200 g (Mynah)	300 g (Pigeon; Sulphur-Crested Cockatoo)	400 g (African Grey Parrot; Eclectus)	500 g (Umbrella Cockatoo)	750 g (Greater Sulphur-Crested Cockatoo)	1000 g (Blue and Gold Macaw)
Epinephrine (1:1000; 1 mg/ml)	0.5–1.0 mg/kg	0.007–0.015 ml	0.015–0.03 ml	0.02–0.05 ml	0.05–0.10 ml	0.1–0.2 ml	0.15–0.3 ml	0.2–0.4 ml	0.25–0.5 ml	0.375–0.75 ml	0.5–1.0 ml
Atropine (0.2–0.5 mg/ml)	0.5 mg/kg	0.006–0.015 ml	0.012–0.03 ml	0.015–0.05 ml	0.04–0.10 ml	0.08–0.20 ml	0.12–0.3 ml	0.16–0.4 ml	0.2–0.5 ml	0.3–0.75 ml	0.4–1.0 ml
Dexamethasone sodium phosphate (4 mg/ml)	2–4 mg/kg	0.007–0.015 ml	0.015–0.03 ml	0.02–0.05 ml	0.05–0.10 ml	0.1–0.2 ml	0.15–0.3 ml	0.2–0.4 ml	0.25–0.5 ml	0.375–0.75 ml	0.5–1.0 ml
Prednisolone sodium succinate (10 mg/ml)	10–20 mg/kg	0.015–0.03 ml	0.03–0.06 ml	0.04–0.10 ml	0.1–0.2 ml	0.2–0.4 ml	0.3–0.6 ml	0.4–0.8 ml	0.5–1.0 ml	0.75–1.5 ml	1.0–2.0 ml
Prednisolone sodium succinate (50 mg/ml)	10–20 mg/kg	0.003–0.006 ml	0.006–0.012 ml	0.008–0.02 ml	0.02–0.04 ml	0.04–0.08 ml	0.06–0.12 ml	0.08–0.16 ml	0.1–0.2 ml	0.15–0.3 ml	0.2–0.4 ml
Doxapram (20 mg/ml)	20 mg/kg	0.015 ml	0.03 ml	0.04–0.05 ml	0.1 ml	0.2 ml	0.3 ml	0.4 ml	0.5 ml	0.75 ml	1 ml
Calcium gluconate (10%) (100 mg/ml)	50–100 mg/kg	0.007–0.015 ml	0.015–0.03 ml	0.02–0.05 ml	0.05–0.1 ml	0.1–0.2 ml	0.15–0.3 ml	0.2–0.4 ml	0.25–0.5 ml	0.37–0.75 ml	0.5–1.0 ml
Fluid (bolus)	25 ml/kg	0.375 ml	0.75 ml	1.0–1.25 ml	2.5 ml	5 ml	7.5 ml	10 ml	12.5 ml	18.7 ml	25 ml
Dextrose (50%) (slow)	1 ml/kg	0.015 ml	0.03 ml	0.04–0.05 ml	0.1 ml	0.2 ml	0.3 ml	0.4 ml	0.5 ml	0.75 ml	1 ml
Sodium bicarbonate (1 mEq/ml)	5 mEq/kg	0.075 ml	0.15 ml	0.2–0.25 ml	0.5 ml	1 ml	1.5 ml	2 ml	2.5 ml	3.75 ml	5 ml
Mannitol (20%) (200 mg/ml)	0.5–2.0 ml/kg	0.0075–0.03 ml	0.015–0.06 ml	0.02–0.10 ml	0.05–0.2 ml	0.1–0.4 ml	0.15–0.6 ml	0.2–0.8 ml	0.25–1.0 ml	0.375–1.5 ml	0.5–2.0 ml
Hetastarch (ml/kg)	10–15 ml/kg	0.15–0.22 ml	0.3–0.45 ml	0.4–0.75 ml	1–1.5 ml	2–3 ml	3–4.5 ml	4–6 ml	5–7.5 ml	7.5–11.25 ml	10–15 ml

a Dose in ml/kg body weight, IV, IO, or IM. If weight is not available, base CPR on approximate weight of species closest in size.

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APPENDIX 45 Disinfectants and antiseptics. ^{a-d,85,434,543}

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Agent	B	T	S	V	F	P	C	Comments
Alcohol (70% ethanol)		✓		✓			✓	
Benzalkonium chloride	✓			✓			✓	Corrosive, toxic; causes burns
Chlorhexidine (Nolvasan, Fort Dodge)	✓			✓	✓		✓	Poor viral activity; poor efficacy against avian polyoma virus
Chlorine dioxide (Dent-A-Gene, Oxyfresh)				✓		✓		Inactivates avian polyoma virus; mix with caution (fumes are toxic until the solution is stable); surfaces must be cleaned before disinfecting
F10 (Health and Hygiene Ltd)	✓		✓	✓	✓			
Formaldehyde		✓	✓				✓	
Formalin	✓	✓		✓				
Glutaraldehyde (Metricide, Metrex; Cidex, Johnson and Johnson; VHA Plus, Bedford Laboratories)		✓	✓		✓		✓	
Hydrogen peroxide	✓		✓	✓				Formerly unstable; new preparations highly stable; 3%-6% used for disinfection, 6%-25% used for sterilization; slowly sporicidal at ambient temperature, but at elevated temperatures activity is markedly increased
Hypochlorite (Clorox, Clorox Co; BioChlor, Ecolab Laboratories)	✓	✓	✓	✓		✓	✓	Quickly inactivated by dirt; much more active in warm water than cold; inactivates avian polyoma virus
Iodophor (Betadine, Purdue Frederick)	✓	✓	✓	✓		✓		Not effective against all strains of <i>Pseudomonas</i> spp.; spores are more resistant to aqueous iodine than iodophor
Organic acids (benzoic and sorbic acids)					✓			
Paraben					✓			
Phenol (Bioguard, Ecolab; Avinol-3, Veterinary Products Lab)	✓	✓		✓			✓	Virucidal activity is very formulation dependent; Avinol-3 effective against avian polyoma virus
Quaternary ammonium (Roccal-D Plus, Pharmacia and Upjohn); benzalkonium chloride	✓			✓	✓		✓	Antibacterial activity is reduced in the presence of organic material; most quaternary ammoniums lose effectiveness when used with fabrics, sponges, or mops that adsorb them; inactivated by soaps, proteins, fatty acids, and phosphates so surfaces must be rinsed well first; Roccal-D Plus is effective against <i>Mycoplasma gallisepticum</i> ; ineffective against avian polyoma virus; some gram-negative bacteria, some viruses, fungi, and protozoa may be resistant to benzalkonium chloride
Quaternary ammonium plus biguanidine complex (F10, Health and Hygiene Products)	✓			✓	✓			Sinus flush, nasal flush, and for nebulization ⁸⁵ ; sporicidal
Washing soda (2%-5%)				✓				Rinsing is required

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a Many of the disinfectants are inactivated by organic material such as dirt or droppings.

b Fungi are more resistant than non spore-forming bacteria (except mycobacteria); fungi are more susceptible than bacterial spores.

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- c Factors contributing to failure of disinfection programs include (1) disinfectant-related (selection ineffective, disinfectant too dilute, insufficient contact time, temperature too low, relative humidity too low for gaseous disinfectants)⁵⁴³ and (2) environmental factors (presence of organic matter, inactivation of quaternary ammonium compounds and biguanides by residual soaps and detergents, incorrect application, inadequate penetration and coverage, interference with quaternary ammonium compounds and biguanides by synthetic materials and plastics).
- d Do not forget the importance of using hot water when disinfecting.

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APPENDIX 46 Vaccines used in birds

(nonpoultry).^{74,83,236,296,315,377,394,417,448,516,522,530,611,651}

Agent	Dosage	Initial	Booster	Species/Comments
<i>Clostridium botulinum</i> type C (Botuminik, United Vaccines)	1 ml SC	Spring	4 wk	Anseriformes, Galliformes, Gruiformes/bacterin toxoid ⁷⁴ ; single immunization of mallard and pintail ducks provided protection at 90 days postimmunization ³⁹⁴
Eastern equine encephalitis (Triple-E, Solvay) (EEE vaccine w/o tetanus, Fort Dodge)	0.5–1.0 ml IM ⁶⁰⁴	6 wk to 3 mo of age	Booster 3–4 wk later, then biannually before and after breeding season (March/Sept) ⁶⁰⁴	Emus; eclectus parrots of all ages are particularly susceptible and should be vaccinated annually in endemic areas ^{516,530}
Eastern equine encephalitis (government distribution strain PE 6 WRAIR) ⁴⁴⁸	0.5 ml–1.0 ml IM ⁴⁴⁸	Vaccinate (0.5 ml) hatchlings immediately at birth; adults initially receive 0.5 ml	Booster juveniles 30 days later; booster adults with 0.5 ml 6 mo later, then 1.0 ml annually	Whooping cranes ⁴⁴⁸
Herpes, duck viral enteritis (duck plague virus) (Intervet)	SC, IM	Vaccinate all susceptible species before risk season; primary, May–June; secondary, Aug–Oct ⁸³	Annually where endemic	Anseriformes/MLV; may be used during an outbreak ⁵¹⁶
Herpes, psittacine (Pacheco's) (Psittimmune PDV, Biomune)	0.25 ml/<100 g SC486 0.25 ml/>100 g SC, IM ⁴⁸⁶	Weaning	4–8 wk, then annually	Psittacines/killed vaccine; complete schedule at least 4 wk before breeding season; vaccinate healthy birds in high-risk situations such as quarantine or retail outlets ^{516,611} Severe granuloma formation may occur rarely at vaccination site; controversial for use in cockatoos
Japanese encephalitis (JE-VAX aka BIKEN, Pasteur Merieux Connaught)	0.25 ml SC (tragopans, pigeons) 0.1 ml SC ^a (gulls, doves) ⁹²			Japanese encephalitis is closely related to West Nile; although the use of JE-VAX appeared safe for all birds, a serologic antibody response was not induced ⁹²
Paramyxovirus-1 (V.P. Vaccin Nobilis Lasota, Intervet)	Apply 1–2 drops in nostrils or eyes Add to drinking water Intranasally or added to drinking water	2–4 wk before shows/races	6–8 wk 8 wk Booster in 3–4 wk; protects approximately 6 mo	Pigeons, exotic doves/MLV; poor immune response Pigeons, exotic doves/1 bottle is administered to entire flock (>100 birds), divided evenly in drinking water for 24 hr; poor immune response Raptors/Hitchner B1 and La Sota strain poultry vaccines in drinking water appear to be effective; may see mild palpebral swelling for a few days ²⁹⁶

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Paramyxovirus-1, pigeon (Inacti/vac PMV1, Maine Biological Lab)	0.5 ml SC ^{a,486}	4 wk of age	4 wk, then annually	Pigeons, doves/killed vaccine; preferred PMV-1 vaccine; vaccinate 1–2 mo before breeding season and 6–8 wk before race or show season; may be given in an outbreak ²³⁶	311
Paramyxovirus-1/Pox, pigeon (Columbovac, Solvay Duphar)	0.2 ml SC ^{a,44}	4 wk of age	—	Pigeons/killed vaccine; poor immunologic response to pox	312
Parvovirus, goose viral hepatitis	—	—	May be necessary	Vaccinate breeders 6 wk before egg production ⁸³	312
Paratyphoid (see <i>Salmonella typhimurium</i>)	—	—	—	—	
Picornavirus, duck viral hepatitis	—	12 wk (MLV) ⁵¹⁶	6 wk (killed)	Vaccinate breeders before laying ⁸³ May vaccinate early in disease process ⁶⁵¹	
Polyomavirus (Avian Polyomavirus Vaccine, Biomune)	0.25 ml/bird (that will weigh <200 g at maturity) SC ^{486,611} 0.5 ml/bird (that will weigh >200 g at maturity) SC ^{486,611}	35–50 days of age; chicks may be safely vaccinated as young as 10–20 days of age; degree of protection uncertain ⁵²²	2–3 wk, then annually; last booster should be given at least 2 wk before leaving aviary ⁵²¹	Psittacines/may cause discoloration, thickening, or granuloma of skin at vaccination site (usually resolves within 8 wk) May be indicated in the face of an out-break ^{b,522} ; the only vaccine for pet and aviary birds that is officially recommended for routine use; registered with United States Department of Agriculture ⁵³⁰	
Pox, canary (Poximune-C, Biomune)	Wing web piercing ⁴⁸⁶	Weaning	6–12 mo and 4 wk before breeding and vector seasons, then annually	Canaries/MLV; a “take” inflammatory reaction or scab should develop at vaccination site May be used in the face of an epidemic in clinically normal birds ^b	312
Pox, pigeon (Acti/vacPP, Maine Biological Lab)	Rub into epilated follicles on thigh or wing web with the use of a dropper or brush; stretch skin to open feather follicles ^{236,486,546}	4 wk of age; vaccinate young birds before racing; vaccinate old birds at least 6 wk before pairing ⁵⁴⁶	Annually	Pigeons/MLV; annual boosters may not be necessary ⁵³⁸ ; booster if exposure Raptors/used successfully in falcons and bustards in the Middle East ^{546,604} Administer 4 wk before mosquito season and ideally after other vaccines are given; immunity develops 3–4 wk after administration ²³⁶ ; vaccinated birds are infectious until vaccine lesions have healed ⁵⁴⁶	313
Pox, psittacine (Maine Biological Lab)	—	—	—	Psittacines/killed vaccine; use in cockatoos is controversial; granuloma formation may occur at vaccination site and require surgical removal	
<i>Salmonella typhimurium</i> • (Sal Bac, Biomune)	0.5 ml SC ^{a,486}	2–3 wk before breeding, races, shows	3–4 wk then semiannually	Pigeons/bacterin; questionable efficacy, possible reduction in fecal shedding, which may contribute to control of salmonellosis ^{236,626} ; complete vaccinations at least 2–3 wk before racing, showing, or egg production	
• (Bespoke, Specialist Laboratories)	0.25 ml IM	—	—	Pigeon/persistent loft problems ⁴⁴ ; birds are often depressed for 12–24 hr postadministration; not available in the United States	313

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West Nile Virus (West Nile-Innovator, Fort Dodge)	0.5–1.0 ml IM	Repeat 2× q3–4 wk	3 wk	Many avian species, including Anseriformes, Ciconiiformes, Columbiformes, Coraciiformes, Passeriformes, Psittaciformes, and raptors/inconsistent antibody response (flamingos, penguins) ^{276,447}	314
Western equine encephalitis (Triple E, Solvay) see Eastern equine encephalitis	1 ml	6 wk	3–4 wk later, then every 6 mo ⁶⁰⁴	—	
<p>a Choose subcutaneous injection site carefully in pigeons to avoid bleeding; cranial to thigh or lower third of neck on dorsal midline.^{236,628}</p> <p>b Vaccinating birds during an outbreak may allow humans to theoretically serve as mechanical vectors.⁵¹⁶</p>					
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5

Sugar Gliders

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TABLE 37 Antimicrobial and antifungal agents used in sugar gliders.^a

Agent	Dosage	Comments
Amoxicillin	30 mg/kg PO, IM divided q12–24h × 14 days ^{17,24} 30 mg/kg IM q24h ¹⁰	
Amoxicillin/clavulanic acid (Clavamox, Pfizer)	12.5 mg/kg PO, SC divided q12–24h ^{24,34}	Injectable form not available in the United States
Cephalexin	30 mg/kg PO, SC divided q12–24h ^{24,34}	Injectable form not available in the United States
Ciprofloxacin	10 mg/kg PO q12h ²⁴	
Enrofloxacin (Baytril, Bayer)	5 mg/kg PO, SC, IM q12h ³⁴	Tissue necrosis may occur when administered parenterally
Gentamicin	2 mg/kg SC, IM divided q12–24h ²⁴	Rarely indicated; use with caution; need concurrent fluid therapy
Itraconazole	5–10 mg/kg PO q12h ³³	
Lincomycin	30 mg/kg IM q24h × 7 days ¹⁰	Dermatitis; dose can be divided q12–24h
Metronidazole	25 mg/kg PO q12h × 7–10 days ¹⁶	
Trimethoprim/sulfamethoxazole	15 mg/kg PO q12h ^{23,30} 50–57 mg/kg PO q24h ¹²	

a Dosages of select drugs may also be based on the low end of ranges for cats, ferrets, or hedgehogs.¹³

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TABLE 38 Antiparasitic agents used in sugar gliders.^a

Agent	Dosage	Comments
Carbaryl powder (5%)	Topical ²	Ectoparasites; use sparingly; can be used in nest boxes
Febantel (F)/pyrantel pamoate (P)	(F) 15 mg/kg + (P) 14.4 mg/kg PO ¹	Roundworms, strongyles
Fenbendazole	20–50 mg/kg PO q24h × 3 days ^{3,24}	Roundworms, hookworms, whipworms; cestodes; lower end of dosage range may be preferable
Ivermectin	0.2 mg/kg SC, repeat in 10–14 days ^{3,24}	Roundworms, hookworms, whipworms; acariasis
Metronidazole	25 mg/kg PO q12h ²⁴	Intestinal protozoa
Oxfendazole	5 mg/kg PO single dose ^{3,30} 10–20 mg/kg PO ¹	Roundworms; cestodes (adult) Roundworms; cestodes (adult)
Pyrethrin powder	Topical ²⁷	Ectoparasites; use products safe for kittens

a Dosages of select antiparasitic agents may also be based on the low end of ranges for cats, ferrets, or hedgehogs.¹³

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TABLE 39 Chemical restraint/anesthetic/analgesic agents used in sugar gliders.^{a,b}

Agent	Dosage	Comments
Acepromazine	—	See butorphanol, ketamine for combinations
Atropine	0.01–0.02 mg/kg SC, IM ²⁴	
Butorphanol (Torbugesic, Fort Dodge)	— 0.5 mg/kg IM q8h ²⁹	Butorphanol combination follows Analgesia
Butorphanol (B)/acepromazine (A)	(B) 1.7 mg/kg ++ (A) 1.7 mg/kg PO ¹²	Postoperative sedation and analgesia to prevent self-trauma to incision site; dilute with normal saline to administer
Diazepam	0.5–1.0 mg/kg IM ¹	Sedation
Enflurane	To effect ²⁴	Anesthesia
Flunixin meglumine (Banamine, Schering-Plough)	0.1–1.0 mg/kg IM q12–24h ^{20,23}	Analgesia; nonsteroidal antiinflammatory; use for up to 3 days
Glycopyrrolate	0.01–0.02 mg/kg SC, IM, IV ¹⁷	Controls salivation during sedation
Isoflurane	5% induction ¹ ; 1%–3% maintenance ^{29,32}	Anesthetic of choice
Ketamine	— 20 mg/kg IM ¹⁰	Ketamine combination follows Followed with isoflurane
Ketamine (K)/acepromazine (A)	(K) 10 mg/kg + (A) 1 mg/kg SC ¹²	Postoperative sedation and analgesia to prevent self-trauma to incision site
Sevoflurane	To effect ²⁴	Anesthesia

- a Dosages of select drugs may also be based on the low end of ranges for cats, ferrets, or hedgehogs.¹³
- b Do not use tiletamine/zolazepam (Telazol, Fort Dodge) because it has caused neurologic syndromes and death in squirrel gliders at doses of 10 mg/kg.⁹

TABLE 40 Miscellaneous agents used in sugar gliders.^a

Agent	Dosage	Comments
Calcitonin	50–100 IU/kg ²⁹	Nutritional osteodystrophy; ensure serum calcium levels are normal before use; salmon origin
Calcium glubionate	150 mg/kg PO q24h ³³	Nutritional osteodystrophy; calcium deficiency
Calcium glycerophosphate/lactate	7 mg/kg ²⁶ IM	Nutritional osteodystrophy; calcium deficiency
Cisapride	0.25 mg/kg q8–24h PO, IM ¹⁷	Gastrointestinal motility enhancer
Dexamethasone	0.1–0.6 mg/kg SC, IM, IV ²⁴ 0.5–2.0 mg/kg SC, IM, IV ¹⁷	Antiinflammatory; allergies Shock
Metoclopramide	0.05 mg/kg PO, SC, IM q6–12h prn ¹⁷	Gastrointestinal motility enhancer
Vitamin A	500–5000 IU/kg IM ²⁴	Skin disorders
Vitamin B complex	0.02–0.2 ml/kg SC, IM ²⁴	Use small animal formulation

- a Dosages of select drugs may also be based on the low end of ranges for cats, ferrets, or hedgehogs.¹³

APPENDIX 48 Biologic and physiologic values of sugar gliders. ^{1,3,6–8,11,21,22,25,31,35–37}

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Parameter	Normal Values
Average life span (wild)	
Male	4–5 yr
Female	5–7 yr
Maximum reported life span	
Captivity	15 yr
Wild	9 yr
Colony size (wild)	7 (avg) (1 dominant male, 2 subordinate males, 4 adult females)
Colony size (captivity)	Minimum 2 (more is better)
Adult weight ^a	Male, 115–160 g (avg, 140 g)
	Female, 95–135 g (avg, 115 g)
Body length	16–21 cm (avg, 17 cm)
Tail length	16.5–21.0 cm (avg, 19 cm)
Heart rate	200–300 beats/min
Respiratory rate	16–40 breaths/min
Cloacal temperature	36.2° C ± 0.4° C (97.2° F ± 0.7° F)
Torpor cloacal temperature	≥15° C (59° F)
Thermoneutral zone	27° C–31° C (81° F–88° F)
Basal metabolic rate	2.54 (weight in kg) ^{0.75}
Estrus cycle	
Type	Seasonally polyestrus
Length	29 days
Gestation period	15–17 days
Litter size	1–2 (usually 2)
Birth weight	0.19 g
Pouch emergence	60–74 days
Weaning age	110–120 days
Dispersal from nest	7–10 mo
Sexual maturity	Male, 12–14 mo; female, 8–12 mo

a Weights are for adult sugar gliders (*Petaurus breviceps breviceps*). Many sugar gliders in the United States are the New Guinean spp., which are smaller. Weights of 80–130 g are more typical. ^{15,23,27,29}

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APPENDIX 49 Hematologic and serum biochemical values of sugar gliders.^a

Measurement	International Species Information System Values ¹¹	Currumbin Sanctuary, Queensland, Australia Values ^{b,3}	Midwest Bird and Exotic Animal Hospital, Illinois Values ^{28,29}
HEMATOLOGY			
PCV (%)	43.9 ± 4.0 (21)	47.6 [40–51] (7)	43.4 ± 12.5 (10)
RBC (10 ⁶ /μl)	7.8 ± 0.9 (20)	7.5 [6.5–8.3] (7)	6.1 ± 1.4 (10)
Hb (g/dl)	15.4 ± 1.6 (21)	15.1 [12.8–16.2] (7)	11.6 ± 4.7 (10)
MCH (pg)	19.9 ± 1.3 (20)	20.2 [18.5–21.9] (7)	—
MCHC (g/dL)	35.1 ± 2.0 (21)	31.8 [31.0–38.8] (7)	—
MCV (fl)	56.8 ± 5.4 (20)	63.7 [57.8–69.6] (7)	—
WBC (10 ³ /μl)	6.7 ± 4.9 (20)	16.3 [9.1–22.8] (7)	8.6 ± 5.1 (10)
Segmented neutrophils (10 ³ /μl)	1.2 ± 1.0 (20)	1.0 [0.5–1.8] (7)	31% ± 16% (10)
Band cells (10 ³ /μl)	0.12 ± 0.05 (2)	—	0% (10)
Lymphocytes (10 ³ /μl)	5.2 ± 4.4 (20)	15.0 [8.3–21.2] (7)	64% ± 17% (10)
Monocytes (10 ³ /μl)	0.18 ± 0.17 (16)	0.05 [0.0–0.23] (7)	3% ± 3% (10)
Eosinophils (10 ³ /μl)	0.18 ± 0.25 (15)	0.23 [0.0–0.99] (7)	2% ± 2% (10)
Basophils (10 ³ /μl)	0.04 (1)	0 (7)	0% (10)
NRBC/100 WBC	2 ± 1 (7)	0 (7)	—
Platelets (10 ³ /μl)	728 ± 176 (3)	—	162 ± 62 (10)
CHEMISTRIES			
AP (IU/L)	196 ± 35 (5)	188 (1)	—
ALT (IU/L)	70 ± 40 (14)	36 [28–44] (3)	100 ± 83 (11)
AST (IU/L)	72 ± 67 (16)	50 [20–70] (3)	147 ± 137 (11)
Bilirubin, total (mg/dl)	0.3 ± 0.2 (13)	—	0.6 ± 0.3 (11)
Calcium (mg/dl)	7.5 ± 3.5 (5)	9.6 (1)	8.0 ± 1.6 (11)
Chloride (mEq/L)	106 ± 1 (4)	105 [101–109] (5)	—
Cholesterol (mg/dl)	161 ± 2 (3)	200 [128–248] (3)	—
CPK (IU/L)	639 ± 477 (5)	224 (1)	2596 ± 3840 (11) ^d
Creatinine (mg/dl)	0.8 ± 0.3 (6)	0.8 [0.2–1.5] (7)	0.4 ± 0.2 (11)
Glucose (mg/dl)	139 ± 78 (15)	50 [5–124] (3) ^c	156 ± 40 (11)
LDH (IU/L)	246 ± 33 (3)	—	—
Phosphorus (mg/dl)	7.0 ± 2.2 (5)	8.1 (1)	4.9 ± 2.8 (11)
Potassium (mEq/L)	3.5 ± 0.7 (4)	5.4 [4.4–6.3] (3)	5.8 ± 3.9 (11)
Protein, total (g/dl)	6.1 ± 0.6 (13)	5.9 [4.0–6.9] (7)	5.6 ± 0.7 (11)
Albumin (g/dl)	4.0 ± 0.7 (6)	3.3 [3.0–3.5] (7)	4.1 ± 0.8 (11)
Globulin (g/dl)	2.3 ± 0.8 (5)	2.6 [0.6–3.0] (7)	—
Sodium (mEq/L)	143 ± 4 (4)	144 [138–158] (4)	137 ± 10 (11)
Urea nitrogen (mg/dl)	17 ± 7 (14)	18 [10–27] (7)	25 ± 9.2 (11)

a Sample size is presented in parentheses and range in brackets.

b Reference ranges for *Petaurus breviceps breviceps*; blood collected from the medial tibial artery.

c Glucose test was performed on whole blood up to 24 hr after collection; values may therefore be invalid.

d In the author's opinion, these values are extremely high and should not be used as a normal reference range.

APPENDIX 50 Growth and development of sugar gliders.^{3,5}

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Age (days)	Weight (g)	Head (mm)	Leg (mm)	Development
1	0.2	—	—	Mouth and forelimbs most developed feature
20	0.8	11	6	Ears free from head; papillae of mystacial vibrissae (whiskers) visible
30	1.6	14	9	—
35	2	—	—	Mystacial vibrissae erupt; ears pigmented
40	3.2	17	12	Start to pigment on shoulders; eye slits present
50	6.2	20	16	—
60	12	23	20	Detaching from teat; fur emerging; dorsal stripe developing
70	24	26	24	Eyes open; fully furred; left in nest
80	34	29	29	Fur lengthens
90	44	32	35	—
100	54	35	—	Emerging from nest; start eating solids
130	78	—	—	Weaned

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APPENDIX 51 Dietary components for sugar gliders in captivity.²

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Fruit	Oranges, watermelon, paw paw (papaya), pears, kiwifruit, apricots, berries, bananas, apples, mangos, grapes, melons, figs
Invertebrates	Mealworms, grasshoppers, moths, fly pupae, crickets
Blossoms and branches	<i>Eucalyptus</i> , <i>Banksia</i> , <i>Leptospermum</i> , <i>Grevillea</i> , <i>Acacia</i> , <i>Melaleuca</i> , <i>Callistemon</i> , <i>Hakea</i>
Supplements	Puppy chow, ^a nectar mix (Gliderade, Avico [Exotic Nutrition Co, Newport News, VA; (757) 930-0301; exoticdiet@cox.net]; Nekton-Lori, Nekton USA), vitamins, minerals (use an oral calcium supplement daily)

a Pelleted diets for sugar gliders are commercially available and may be preferable.

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APPENDIX 52 Suggested sugar glider diets.^{4,18}

DIET 1^{a,4}

Items (mixed into a slurry)	% of diet by weight	Amount (g) per adult animal
• Chopped, mixed fruit ^b	40	12.0
• Cooked, chopped vegetables ^c	8	2.5
• Peach or apricot nectar	34	10.0
• Ground, dry, low-iron bird diet ^d	18	5.5
Total	100	30.0

DIET 2^{a,e14}

- 50% Leadbeater's mixture (150 ml warm water; 150 ml honey; 1 shelled, hard-boiled egg; 25 g high-protein baby cereal; 1 tsp vitamin/mineral supplement)
- Mix warm water and honey
 - In separate container, blend egg until homogenized
 - Gradually add honey/water, then vitamin powder, then baby cereal, and blend after each addition until smooth
 - Keep refrigerated until served
- 50% Insectivore/omnivore diet (e.g., Mazuri Brand, Purina Mills, St. Louis, MO; Reliable Protein Products, Palm Desert, CA; ZuPreem, Mission, KS)^f

DIET 3^{g,15,19}

- Apple: 3 g; banana/corn: 3 g; grapes/kiwifruit: 3 g; orange with skin: 4 g; pear: 2 g; rockmelon/melon/paw paw (payaya): 2 g
- Sweet potato: 3 g
- Dog kibble: 1.5 g; fly pupae: 1 tsp^f
- Leadbeater's mix (see above): 2 tsp
- Day-old chick (1 day a week)
- Large insects or mealworms (when available)

a Insects can be added to this diet to help prevent dental problems.

b Any fruit, but less than 10% citrus; some have recommended diets consisting of 70% fruit.

c Steamed or microwaved; 50:50 starchy/nonstarchy vegetables (e.g., 50% sweet potato, 50% carrot).

d Zeigler Lo-iron Bird of Paradise pellets (Zeigler Brothers, Inc., Gardners, PA) or Marion Zoological Red Apple Jungle Scenic Birdfood (Marion Zoological Scenic Birdfoods, Plymouth, MN).

e Feed fresh portions in evening; chop items together to reduce only favorite foods being selected. Can offer treats (meats, diced fruits with multiple vitamin/mineral powder, bee pollen, worms, and crickets and other gut-loaded insects) at \approx 5% of daily intake.

f Pelleted sugar glider food (e.g., Marion Zoological) might be preferable to other dry omnivore diets.

g Recipe feeds two animals; without native foods (e.g., in North America), add calcium carbonate to this diet.

APPENDIX 53 Feed estimates for hand-rearing sugar gliders.^{a,b,c,d,5}

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Age (days)	Feed (ml/day)	Wombaroo Milk Replacer
20	0.7	Formula #2
30	1.1	
40	1.8	
50	3	
51–53	4 (3 ml [#2] + 1 ml [#1])	Transition from Formula #2 to Formula #1
54–56	4 (2 ml [#2] + 2 ml [#1])	
57–59	4 (1 ml [#2] + 3 ml [#1])	
60	3	Formula #1
70	4	
80	6	
90	7	
100	8	

- Using [Appendix 50](#), estimate the age of the sugar glider by using head, leg (toe to heel), and weight measurements. Once you know the approximate age of the sugar glider, use this appendix to determine how much to feed it. Note: in an emaciated joey, the head and leg measurements may be more accurate than the animal's weight to determine age.
- Using [Appendix 53](#), note that marsupial milk changes in composition and energy as the joey develops. Therefore there are two formulas of Wombaroo Milk Replacer that are used for hand-rearing sugar gliders. Formula #2 is for younger joeys; Formula #1 is for gliders out of the pouch. When a joey has fully emerged from the pouch, it then uses Formula #1 entirely.
- Wombaroo Milk Replacer is available in the United States from the Exotic Nutrition Co., Newport News, VA. (757) 930-0301, or exoticdiet@cox.net.
- For hand-rearing procedures, refer to Barnes¹ and Ness and Booth.³⁰

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5.1 APPENDIX 54 Literature cited—sugar gliders.

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6



Hedgehogs

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TABLE 41 Antimicrobial agents used in hedgehogs.

Agent	Dosage	Comments
Amikacin	2.5–5.0 mg/kg IM q8–12h ¹⁵	
Amoxicillin	15 mg/kg PO, SC, IM q12h ^{9,25}	
Amoxicillin/clavulanic acid (Clavamox, Pfizer)	12.5 mg/kg PO q12h ^{19,27}	
Ampicillin	10 mg/kg PO, IM q12h ^{9,11,25}	
Ceftiofur (Naxcel, Pharmacia & Upjohn)	20 mg/kg SC q12–24h ¹⁵	
Cephalexin (Keflex, Dista)	25 mg/kg PO q8h ¹⁵	
Chloramphenicol	30 mg/kg IM q12h ^{9,11} 30–50 mg/kg PO, SC, IM, IV q12h ²⁵ 50 mg/kg PO, SC, IM q12h ^{8,9,11}	Acute salmonellosis
Chlorhexidine (Nolvasan, Fort Dodge)	Topical ²⁵	Wound treatments; soaking (e.g., appendages); use properly diluted
Chlorhexidine shampoo (Hexadene, Virbac)	2%–3% shampoo ¹⁵	Bacterial/fungal dermatitis
Ciprofloxacin	5–20 mg/kg PO q12h ¹⁹	
Clindamycin (Antirobe, Pharmacia & Upjohn)	5.5–10.0 mg/kg PO q12h ^{15,27}	Anaerobes; dental disease
Enrofloxacin (Baytril, Bayer)	2.5–5.0 mg/kg PO, IM ²² q12h 5–10 mg/kg PO, SC, IM q12h ^{8,25}	
Erythromycin	10 mg/kg PO, IM q12h ^{9,11}	Penicillin-resistant grampositive cocci; <i>Mycoplasma</i> ; <i>Pasteurella</i> ; <i>Bordetella</i>
Gentamicin	2 mg/kg SC, IM q8h ⁸	Rarely indicated
Gentamicin ophthalmic drops	Topical to cornea or conjunctiva ¹⁵	Corneal abrasions or conjunctivitis; use as in dog or cat
Metronidazole	20 mg/kg PO q12h ^{15,19}	Anaerobes
Mupirocin (2%) (Bactroban, GlaxoSmithKline)	Topical to cutaneous lesions q12–24h prn ¹⁵	Bacterial dermatitis or traumatic skin lesions
Nystatin, neomycin, thiostrepton, triamcinolone cream (Panalog, Fort Dodge)	Topical to cutaneous lesions q12–24h prn ¹⁵	Bacterial/mycotic dermatitis; antiinflammatory
Oxytetracycline	25–50 mg/kg PO q24h ^{6,15}	<i>Bordetella</i> ; may be administered in food
Penicillin G	40,000 IU/kg SC, IM q24h ^{9,19}	
Piperacillin	10 mg/kg SC q8–12h ¹⁵	
Spiramycin	15 mg/kg PO × 8 days ⁹	Gingivitis; frequency not listed; not available in the United States
Sulfadimethoxine	2–20 mg/kg PO, SC, IM q24h ^{8,9}	
Terramycin ophthalmic ointment	Topical to cornea or conjunctiva ¹⁵	Corneal abrasions or conjunctivitis; use as in dog or cat
Thiabendazole, dexamethasone, neomycin solution (Tresaderm, Merial)	Topical to cutaneous lesions or ear canal q12h prn ¹⁵	Bacterial/mycotic dermatitis; otitis externa; antiinflammatory
Trimethoprim/sulfa	30 mg/kg PO, SC, IM q12h ^{8,22}	Respiratory infections
Triple antibiotic ophthalmic ointment	Topical to cornea or conjunctiva ¹⁵	Corneal abrasions or conjunctivitis; use as in dog or cat

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Tylosin (Tylan, Elanco)	10 mg/kg PO, SC q12h ^{11,18}	<i>Mycoplasma; Clostridium</i> ; do not administer IM (causes muscle necrosis)
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TABLE 42 Antifungal agents used in hedgehogs.

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Agent	Dosage	Comments
Chlorhexidine (Nolvasan, 2%-3% shampoo ¹⁵ Fort Dodge)		Dermatophytosis
Enilconazole (Imaverol, Janssen)	Topical q24h ²⁷	Dermatophytosis; dilute 1:50
Griseofulvin (microsize)	— 25 mg/kg PO q12h ⁹ 50 mg/kg PO q24h ^{9,25} × 14–21 days ¹⁶	Skin and deep mycoses; long-term therapy
Itraconazole (Sporonox, Ortho Biotech)	5–10 mg/kg PO q12–24h ¹⁵	Systemic mycoses
Ketoconazole	10 mg/kg PO q24h × 6–8 wk ^{9,25}	Mycoses; use long term
Lime sulfur	Topical ⁷	Dermatophytosis
Nystatin	30,000 IU/kg PO q8–24h ¹⁵	Yeast infections

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TABLE 43 Antiparasitic agents used in hedgehogs.

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Agent	Dosage	Comments
Amitraz (Mitaban, Pharmacia & Upjohn)	0.3% topical q7d × 2–3 treatments ^{14,15}	Mites (<i>Caparinia</i> , <i>Chorioptes</i> , etc.); may dilute; use with caution
Fenbendazole	10–15 mg/kg PO q14d ²⁵ × 2–3 treatments 10–30 mg/kg PO q24h × 5 days ¹¹ 25 mg/kg PO ¹⁵ q10d	Nematodes Nematodes (e.g., <i>Crenosoma</i> , <i>Capillaria</i>) Nematodes
Flea products (feline)	Topical ⁷	Use sparingly
Ivermectin	0.2 mg/kg PO, SC q14d × 3 treatments ²⁵ 0.2–0.4 mg/kg PO, SC q10–14d × 3–5 treatments ^{10,19} 0.5 mg/kg PO, SC q14d × 3 treatments ³	Mites (<i>Caparinia</i> , etc.); nematodes; a pyrethrin-based shampoo q7d × several treatments is often needed concurrently for full response Ectoparasites Mites; resistance to the lower doses of ivermectin has been noted
Levamisole (1%)	10 mg/kg SC, ⁶ repeat q48h; repeat prn q14d ⁹	Nematodes, including lungworms
Metronidazole	25 mg/kg PO q12h × 5 days ^{7,25}	Intestinal protozoa
Permethrin (1%)	Topical ²⁶	Mites; apply once with fine mist; change bedding
Praziquantel (Droncit, Bayer)	7 mg/kg PO, SC, repeat q14d ^{7,25}	Cestodes, trematodes
Selamectin (Revolution, Pfizer)	6 mg/kg topically ⁴	Ectoparasites
Sulfadimethoxine	2–20 mg/kg PO, ⁹ SC, IM ¹¹ q24h × 2–5 days, off 5 days, on 2–5 days ⁹ 10 mg/kg PO q24h × 5–7 days ¹⁵	Coccidia Coccidia
Sulfadimidine	100–200 mg/kg SC q24h × 3 days ⁶	Coccidia

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TABLE 44 Chemical restraint/anesthetic/analgesic agents used in hedgehogs.

Agent	Dosage	Comments
Atipamezole (Antisedan, Pfizer)	0.3–0.5 mg/kg IM ²⁷ 1.0 mg/kg IM ¹	Reversal of medetomidine
Atropine	0.01–0.04 mg/kg SC, IM ¹⁹	Preanesthetic
Buprenorphine (Buprenex, Reckitt & Colman)	0.01 mg/kg SC, IM q6–8h ^{6,24,27} 0.01–0.50 mg/kg IM, SC q8–12h ¹²	Analgesia Analgesia
Butorphanol (Torbugesic, Fort Dodge)	0.05 mg/kg SC q8h prn ¹¹ 0.05–0.10 mg/kg SC, IM q8–12h ¹² 0.2–0.4 mg/kg SC, IM q6–8h ^{24,25}	Analgesia Analgesia Analgesia
Diazepam	0.5–2.0 mg/kg IM ²²	Mild sedation; may be given with ketamine for anesthesia; seizures
Enflurane	To effect ¹⁹	Anesthesia
Fentanyl	—	See medetomidine for combination
Flunixin meglumine (Banamine, Schering-Plough)	0.03 mg/kg IM q8h ¹² 0.3 mg/kg SC q24h ¹²	Nonsteroidal antiinflammatory
Halothane	To effect ⁴	Rarely used; less preferable than isoflurane
Isoflurane	3%–5% induction ²⁵ 0.5%–3.0% maintenance ^{24,25}	Anesthetic of choice; generally occurs in an induction chamber or mask By mask or endotracheal tube
Ketamine	— 5–20 mg/kg IM ²²	See medetomidine for combinations Sedation; anesthesia; do not use in neck area where there is brown fat ¹¹ ; may use in combination with diazepam or xylazine; recovery may be prolonged and/or rough
Ketamine (K)/diazepam (D)	(K) 5–20 mg/kg + (D) 0.5–2.0 mg/kg IM ³	Anesthesia
Medetomidine (Domitor, Pfizer)	— 0.05–0.10 mg/kg IM ^{15,27} 0.2 mg/kg SC, IM ²	Medetomidine combinations follow Light sedation; reverse with atipamezole Heavy sedation; reverse with atipamezole
Medetomidine (M)/ketamine (K)	(M) 0.1 mg/kg + (K) 5 mg/kg IM ²⁷	Anesthesia; (M) can be reversed with atipamezole (0.3–0.5 mg/kg IM)
Medetomidine (M)/ketamine (K)/fentanyl (F)	(M) 0.2 mg/kg + (K) 2 mg/kg + (F) 0.1 mg/kg SC ¹	Anesthesia; good muscle relaxation; (M) can be reversed with atipamezole (1 mg/kg IM) and (F) can be reversed with naloxone (0.16 mg/kg IM)
Naloxone	0.16 mg/kg IM ¹	Reversal of fentanyl
Sevoflurane	To effect ¹⁹	Anesthesia
Tiletamine/zolazepam (Telazol, Fort Dodge)	1–5 mg/kg IM ²⁵	Sedation; anesthesia; recovery may be prolonged and/or rough
Xylazine	0.5–1.0 mg/kg IM ²²	Anesthesia; may be given with ketamine
Yohimbine	0.5–1.0 mg/kg IM ¹⁹	Reversal of xylazine

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TABLE 45 Miscellaneous agents used in hedgehogs.

Agent	Dosage	Comments
Calcium gluconate (10%)	0.5 mg/kg IM ⁹ 50 mg/kg IM ¹⁵	Fracture repair Hypocalcemia
Cimetidine	10 mg/kg PO q8h ¹⁵	Treatment of gastric ulcers
Dexamethasone	0.1–1.5 mg/kg IM ⁹ 1–4 mg/kg SC, IM, IV ¹⁵	Inflammation; allergies Shock
Enalapril (Enacard, Merck)	0.5 mg/kg PO q24h ¹⁵	Vasodilator; heart failure
Erythropoietin (Epogen, Amgen)	100 U/kg SC q48–72h ¹⁵	Chronic anemia
Flunixin meglumine (Banamine, Schering-Plough)	0.03 mg/kg IM q8h ¹² 0.3 mg/kg SC q24h ¹²	Arthritis; chronic inflammation Arthritis; chronic inflammation
Furosemide	2.5–5.0 mg/kg PO, SC, IM q8h ^{19,27}	Edema; diuretic
Hyaluronidase (Wydase, Wyeth)	100–150 U/L ¹⁵	Add to SC fluids; facilitates fluid absorption
Iron dextran	25 mg/kg IM ²⁷	Anemia
Lactobacilli	½ tsp/kg q24h ⁹	May aid in restoring gastrointestinal flora
Lactulose	0.3 ml/kg PO q8–12h ¹⁵	Hepatic disease
Methylprednisolone	1–2 mg/kg SC ¹⁵	Antiinflammatory
Metoclopramide	0.2–0.5 mg/kg PO, SC ¹⁵	Regurgitation
Prednisolone	2.5 mg/kg PO, SC, IM q12h prn ^{9,19} 10 mg/kg SC, IM ⁹	Allergies Shock
Sucralfate (Carafate, Hoechst Marion Roussel)	10 mg/kg PO q8–12h ¹⁹	Gastrointestinal ulcers
Theophylline	10 mg/kg PO, IM q12h ¹⁵	Bronchodilator
Vitamin A	400 IU/kg IM q24h × 10 days ⁹	Skin disorders; excessive spine loss
Vitamin B complex	1 ml/kg SC, IM ^{11,19}	CNS signs; paralysis of unknown origin; anorexia; use small animal formulation
Vitamin C	50–200 mg/kg PO, SC q24h ⁹	Deficiency; infections; gingival disease; can use 1 g ascorbic acid/L drinking water (change daily)
Vitamins, multiple	<1 drop/kg PO q24h ⁴	Subclinical deficiency; hand-rearing orphans

APPENDIX 55 Hematologic and serum biochemical values of hedgehogs.²⁰

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Measurement	Reference Range
HEMATOLOGY	
PCV (%)	36 ± 7 (22–64)
RBC (10 ⁶ /μl)	6 ± 2 (3–16)
Hb (g/dl)	12.0 ± 2.8 (7.0–21.1)
MCV (fl)	67 ± 9 (41–94)
MCH (pg)	22 ± 4 (11–31)
MCHC (g/dl)	34 ± 5 (17–48)
Platelets (10 ³ /μl)	226 ± 108 (60–347)
WBC (10 ³ /μl)	11 ± 6 (3–43)
Neutrophils (10 ³ /μl)	5.1 ± 5.2 (0.6–37.4)
Lymphocytes (10 ³ /μl)	4.0 ± 2.2 (0.9–13.1)
Monocytes (10 ³ /μl)	0.3 ± 0.3 (0.0–1.6)
Eosinophils (10 ³ /μl)	1.2 ± 0.9 (0.0–5.1)
Basophils (10 ³ /μl)	0.4 ± 0.3 (0.0–1.5)
CHEMISTRIES	
Alkaline phosphatase (IU/L)	51 ± 21 (8–92)
ALT (IU/L)	53 ± 24 (16–134)
Amylase (IU/L)	510 ± 170 (244–858)
AST (IU/L)	34 ± 22 (8–137)
Bilirubin, total (mg/dl)	0.3 ± 0.3 (0.0–1.3)
BUN (mg/dl)	27 ± 9 (13–54)
Calcium (mg/dl)	8.8 ± 1.4 (5.2–11.3)
Chloride (mEq/L)	109 ± 10 (92–128)
Cholesterol (mg/dl)	131 ± 25 (86–189)
Creatine kinase (IU/L)	863 ± 413 (333–1964)
Creatinine (mg/dl)	0.4 ± 0.2 (0.0–0.8)
GGT (IU/L)	4 ± 1 (0–12)
Glucose (mg/dl)	89 ± 30
LDH (IU/L)	441 ± 258 (57–820)
Phosphorus (mg/dl)	5.3 ± 1.9 (2.4–12.0)
Potassium (mEq/L)	4.9 ± 1.0 (3.2–7.2)
Protein, total (g/dl)	5.8 ± 0.7 (4.0–7.7)
Albumin (g/dl)	2.9 ± 0.4 (1.8–4.2)
Globulin (g/dl)	2.7 ± 0.5 (1.6–3.9)
Sodium (mEq/L)	141 ± 9 (120–165)
Triglycerides (mg/dl)	38 ± 22 (10–96)

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APPENDIX 56 Biologic and physiologic values of hedgehogs. ^{10,13,17,21,23,25,28}

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Parameter	Physiologic Value
Weight	Male, 400–600 g Female, 300–600 g
Life span	Avg 4–6 yr, may live 8 yr
Temperature, rectal	95.7° F–98.6° F (35.4° C–37.0° C)
Preferred environmental temperature	75° F–85° F (25° C–30° C)
Adult dental formula	2 (I3/2:C1/1:P3/2:M3/3) = 36; variations have been noted
Gastrointestinal transit time	12–16 hr
Heart rate	180–260 beats/min
Respiratory rate	25–50 breaths/min
Age at sexual maturity	Male, 6–8 mo Female, 2–6 mo
Reproductive lifespan	Male, throughout life Female, 2–3 yr
Gestation	34–37 days
Milk composition	Protein, 16 g/100 g; carbohydrate, trace; fat, 25.5 g/100 g
Litter size	3–4 (range, 1–7)
Birth weight	10–18 g
Eyes open	14–18 days
Deciduous teeth eruption	Begins on day 18; all deciduous teeth erupted by 9 wk
Permanent teeth eruption	Begins at 7–9 wk
Age at weaning	4–6 wk (start eating solids at 3 wk)

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8:1 APPENDIX 57 Suggested diets for hedgehogs. ^{5,10,11,21,22}

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The natural diet of hedgehogs includes insects, worms, snails, slugs, and, occasionally, small vertebrates and fruit. In captivity, insectivorous mammals are traditionally fed diets that are 30%-50% protein and 10%-20% fat (dry matter basis). Although scientific studies regarding hedgehog nutritional needs are lacking, commercial diets appear to be the most balanced diet that a pet owner can offer. If hedgehog food is not used, premium food for less active cats should form the basis of the diet. Depending on the animal's weight and activity, 1-2 tablespoons of the main diet is typically fed daily. Growing animals and reproductively active females may be fed the usual diet ad libitum, and calcium-rich foods should be supplemented.

In addition to the main diet, 1-2 tsp of varied moist foods (e.g., canned cat or dog food, cooked meat or egg, low-fat cottage cheese) and approximately ½ tsp of fruit (e.g., banana, grape, apple, pear, berries) or vegetables (e.g., beans, cooked carrots, squash, peas, tomatoes, leafy greens) should also be provided daily. One key to balanced nutrition is to provide variety. Acceptable treats include mealworms, earthworms, waxworms, crickets, and cat treats; these may be hidden in the bedding to promote foraging activity.

Do not overfeed hedgehogs because of potential obesity; amounts can be adjusted up or down to meet special nutritional situations (e.g., pregnancy, obesity). Hedgehogs are generally fed once a day in the evening.

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8:2 APPENDIX 58 Hand-rearing orphaned hedgehogs. ^{10,21,23}

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1. Leave neonates with mother if possible for first 24-72 hr for colostrum ingestion.

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2. In cases of lactation failure or abandonment by the female, fostering the pups to another dam with similarly aged pups is generally successful.
3. Feed a canine milk replacer with added lactase (Lactaid, McNeil-PPC, Ft. Washington, PA) with a 1 mL syringe with a catheter tip or an eye dropper.
4. Neonates should be fed as much as they will consume every 2-4 hr for about 3 weeks; the time between feedings can then be gradually lengthened. The newborns should gain 1-2 g/day during the first week, approximately 3-4 g/day during the second week, 4-5 g/day during the third and fourth weeks, and 7-9 g/day until they are 60 days old. At 4-6 weeks, parent- or hand-raised young should be weaned by offering canned dog or cat food, minced beef, or freshly molted mealworms. Hand-rearing hedgehogs is often associated with a high mortality rate.
5. The ambient temperature should be maintained at 90° F–95° F (32° C–37° C) for the first few weeks.
6. Manual stimulation is required for defecation and should be performed after each meal by massaging the ventrum and perineal area with a cloth or swab moistened in warm water.

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6.3 APPENDIX 59 Literature cited-hedgehogs.

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Rodents

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TABLE 46 Antimicrobial and antifungal agents used in rodents.^a

Agent	Dosage	Species/Comments
Amikacin	5 mg/kg SC, IM q8–12h ^{49,65} 8–16 mg/kg divided SC, IM, IV q8–24h ⁸ 10 mg/kg SC, IM q12h ^{12,49} 10 mg/kg SC, IM q12h ^{49,63} 10–15 mg/kg divided SC, IM, IV q8–24h ⁶³ 15 mg/kg IM q12h ⁴⁴	All species Hamsters/also administer fluid therapy Mice, rats, hamsters, gerbils Chinchillas, guinea pigs High peak dosing regimen as efficacious as divided regimens
Ampicillin	— 6–30 mg/kg PO q8h ³ 20–50 mg/kg PO, SC, IM q12h ⁴⁹	Do not use in hamsters, guinea pigs, chinchillas; may cause enterocolitis ¹ Gerbils Mice, rats
Amphotericin B (Fungizone, Bristol-Meyers Squibb)	0.11 mg/kg SC ¹ 0.43 mg/kg PO ¹	Mice/use with caution; may cause renal toxicity Mice/candidiasis
Captan powder (Orthocide, Chevron)	1 tsp/2 cups dust ³¹	Chinchillas/fungicide to prevent spread of dermatophytes between cagemates; add to dust box
Carbenicillin	100 mg/kg PO q12h ³ 200 mg/kg IP ¹	Mice, rats Mice
Ceftiofur	1 mg/kg IM q24h ²⁴	Guinea pigs/pneumonia
Cephalexin	50 mg/kg PO, IM divided q12–24h ^{49,58}	Guinea pigs
Cephalexidine	10–25 mg/kg IM q8–24h ³ 10–25 mg/kg SC, IM q24h ³	Guinea pigs Hamsters, mice, rats
Chloramphenicol	20–50 mg/kg PO q6–12h ⁶⁰ 30–50 mg/kg PO, SC, IM, IV q8–12h ⁸ 30–50 mg/kg PO, SC, IM q8–12h ^{9,16,49} 50 mg/kg PO q8–12h ^{9,16,49,65} 50 mg/kg PO, SC, IM q12h ⁴⁹ 0.5 mg/ml drinking water ⁹ 0.83 mg/ml drinking water ⁹ 1 mg/ml drinking water ⁹	All species All species Hamsters, mice, rats Chinchillas, guinea pigs Prairie dogs Mice Gerbils Guinea pigs
Chloramphenicol ophthalmic ointment	Topical to eyes q6–12h ⁵⁹	All species
Chlortetracycline	10 mg/kg SC, IM q12h ^{2,49} 20 mg/kg PO, SC, IM q12h ^{2,49} 25 mg/kg PO, SC, IM q12h ^{2,49} 50 mg/kg PO q12h ²	Rats Hamsters Mice Chinchillas
Ciprofloxacin (Cipro, Bayer)	— 5–20 mg/kg PO q12h ⁴⁹ 5–15 mg/kg PO q12–24h ⁴⁹ 7–20 mg/kg PO q12h ²⁵ 10 mg/kg PO q12h ^{1,66} 10–20 mg/kg PO q12h ¹²	May cause arthropathies in young Prairie dogs Chinchillas, guinea pigs All species Guinea pigs, hamsters, gerbils, mice, rats Hamsters

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Doxycycline	2.5 mg/kg PO q12h ² 5 mg/kg PO q12h ²⁵ 70–100 mg/kg SC, IM q7d ^{48,49}	All species Mice, rats/pneumonia; may give in combination with enrofloxacin; do not use in young and pregnant animals Mice, rats/use long-acting formulation	
Enilconazole	— Dip in a 0.2% solution q7d ^{1,59}	Dermatophytosis Mice	
Enrofloxacin (Baytril, Bayer)	— 5–10 mg/kg PO, IM q12h ^{25,49} 5–15 mg/kg PO, SC, IM q12h ⁸ 5–20 mg/kg SC, PO q24h ¹ 25–85 mg/kg q24h × 14 days ²³ 0.05–0.2 mg/ml drinking water × 14 days ²⁵ 0.1 mg/ml drinking water ⁶⁶	May cause arthropathies in young; limit SC, IM injections; SC injections can be diluted in NaCl or lactated Ringer's solution Hamsters, mice, rats, prairie dogs/may combine with doxycycline for <i>Mycoplasma</i> in rats Chinchillas, guinea pigs Mice/pasteurellosis Hamsters, gerbils, mice, rats	378
Enrofloxacin (E)/doxycycline (D)	10 mg/kg (E) + 5 mg/kg (D) PO q12h ⁵³	Rats/ <i>Mycoplasma</i>	379
Erythromycin	— 20 mg/kg PO q12h ^{49,68} 0.13 mg/ml drinking water ¹⁰	Do not use in chinchillas, guinea pigs, hamsters (or use with caution) ⁴⁹ Mice, rats Hamsters/outbreaks of proliferative ileitis; use with caution: can cause enterotoxemia	
Furazolidone	30 mg/kg PO q24h ⁹ 5.5 mg/ml drinking water ⁹	Hamsters Guinea pigs	
Gentamicin	2 mg/kg IM q12h ¹ 2–4 mg/kg SC, IM q8–24h ²⁵ 4–20 mg/kg IM q12h ¹ 5 mg/kg SC, IM q24h ^{3,9,16} 5–8 mg/kg SC, IM divided q8–12h ^{49,63} 5–10 mg/kg SC, IM divided q8–12h ⁴⁹ 6 mg/kg SC q24h ¹¹ 20 mg/kg SC q24h ¹ 10 mg/kg drinking water or topical ¹⁸	Chinchillas/bacterial enteritis; <i>Pseudomonas</i> All species Mice All species Chinchillas, guinea pigs, hamsters Mice, rats Guinea pigs Rats Gerbils/nasal dermatitis	
Griseofulvin	— 15–25 mg/kg PO q24h × 14–28 days ⁵⁴ 25 mg/kg PO q24h × 14–28 days ^{38,49} 25 mg/kg PO q24h × 30–60 days ³⁴ 25–50 mg/kg PO q12h × 14–60 days ²⁵ 25–50 mg/kg PO q24h ¹² 250 mg/kg PO q10d × 4 treatments on feed ³⁷ 1.5% in DMSO topical × 5–7 days ²⁵	Dermatophytosis; do not use in pregnant animals; can cause diarrhea, leukopenia, anorexia ²⁵ Guinea pigs/doses up to 100 mg/kg have been used Chinchillas, hamsters, mice, rats, prairie dogs Chinchillas/use with lime sulfur dips All species Hamsters Prairie dogs All species	379

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Itraconazole	2.5–10.0 mg/kg q24h ¹ 5 mg/kg q24h ¹ 50–150 mg/kg q24h ¹	Rats/vaginal candidiasis Guinea pigs/systemic candidiasis Mice/blastomycosis	380
Ketoconazole	10–40 mg/kg PO q24h × 14 days ¹ 10 mg/kg PO q24h ¹² 20 mg/kg q24h ¹	All species/systemic mycoses; candidiasis Hamsters Rats	
Lime sulfur dip	Dip q7d × 4–6 treatments ^{3,49}	All species/dermatophytosis; dilute 1:40 with water	
Metronidazole	— 10–20 mg/kg PO q12h ⁴⁹ 10–40 mg/kg PO q24h ⁴⁹ 20 mg/kg PO q12h ⁴⁹ 20 mg/kg PO q12h × 3–5 days ⁸ 20–40 mg/kg PO q12h ⁴⁹ 2.5 mg/ml drinking water × 5 days ⁹	Anaerobes; add sucrose for palatability Chinchillas/use with caution Mice, rats Guinea pigs All species Prairie dogs Mice	
Neomycin	15 mg/kg PO q12h ^{3,49} 25 mg/kg PO q12h ⁴⁹ 0.5 mg/ml drinking water ³ 2.6 mg/ml drinking water ³	Chinchillas, guinea pigs Mice, rats, prairie dogs Hamsters/proliferative ileitis Mice, rats, gerbils	
Netilmicin	6–8 mg/kg SC, IM, IV divided q8–24h ⁶³	Chinchillas, guinea pigs/ <i>Pseudomonas</i>	
Oxytetracycline	5 mg/kg IM q12h ^{1,3} 10 mg/kg PO q8h ^{9,16} 10–20 mg/kg PO q8h ⁹ 16 mg/kg SC q24h ^{9,16} 50 mg/kg PO q12h ¹⁶ 60 mg/kg IM q3d ⁶⁰ 100 mg/kg SC q24h ⁶⁰ 0.25–1.0 mg/ml drinking water ^{9,16} 0.4 mg/ml drinking water ^{9,16} 0.8 mg/ml drinking water ^{9,16}	Guinea pigs/toxicity in guinea pigs reported ⁵⁴ Gerbils Mice, rats/Tyzer's disease (mice); <i>Mycoplasma pneumonia</i> (rats) Hamsters Chinchillas, guinea pigs/toxicity in guinea pigs reported ³⁹ All species All species Hamsters Mice, rats Gerbils	380
	1 mg/ml drinking water ¹⁶ 3 g/L in drinking water ⁶⁰	Chinchillas, guinea pigs/toxicity in guinea pigs reported ⁵⁴	381
Penicillin G	— 22000 IU/kg SC, IM q24h ⁴⁹	Do not use in guinea pigs, chinchillas Rats	
Penicillin (benzathine and procaine)	— 22000 IU IM q24h ⁶³	Do not use in chinchillas, guinea pigs Rats	
Sulfadimethoxine	10–15 mg/kg PO q12h ²⁵	All species	
Sulfamerazine	0.8 mg/ml drinking water ³ 1 mg/ml drinking water ³ 1 mg/4 g feed ⁹	Gerbils Chinchillas, hamsters, guinea pigs, mice, rats Mice, rats	
Sulfamethazine	0.8 mg/ml drinking water ³ 1 mg/ml drinking water ³	Gerbils Chinchillas, hamsters, guinea pigs, mice, rats	

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Sulfaquinoxaline	0.25–1.0 mg/ml drinking water ⁹ 1 mg/ml drinking water ¹⁶ 0.05% feed ⁹	Rats Chinchillas, gerbils, guinea pigs, hamsters, mice Rats	
Terbinafine	10–30 mg/kg PO q24h × 4–6 wk ³²	Antifungal	
Tetracycline	10 mg/kg PO q8–12h ⁴⁹ 10 mg/kg PO q24h ¹ 10–20 mg/kg PO q8–12h ⁹ 20 mg/kg PO q12h ¹ 20 mg/kg IM q24h ³ 0.3–2.0 mg/ml drinking water ⁹ 0.4 mg/ml drinking water ^{3,9,10} × 10 days 0.7 mg/ml drinking water ⁹ 2–5 mg/ml drinking water ⁹ 0.1%–0.5% feed × 14 days ⁹	Guinea pigs/use with caution: toxicity reported ⁵⁴ Guinea pigs/use with caution: toxicity reported ⁵⁴ Hamsters, gerbils, mice, rats, prairie dogs Chinchillas, guinea pigs, mice, rats Gerbils Chinchillas Hamsters/outbreaks of proliferative ileitis ¹⁰ Guinea pigs/toxicity in guinea pigs reported ⁵⁴ Gerbils, mice, rats Rats	381
Trimethoprim/sulfa	— 15–30 mg/kg PO, SC q12h ^{1,49} 30 mg/kg PO, SC, ¹⁶ IM ²⁵ q12h 48–96 mg/kg PO q24h ¹	Tissue necrosis may occur when given SC ²⁵ Chinchillas, guinea pigs, hamsters, mice, rats, prairie dogs All species Rats	382
Tylosin (Tylan, Elanco)	2–8 mg/kg PO, SC, IM q12h ^{9,16} 10 mg/kg PO, SC, IM q12h ^{38,49} 10 mg/kg PO, SC, IM q24h ¹⁶ 0.5 mg/ml drinking water ^{14,16}	Hamsters/use with caution Chinchillas, guinea pigs, mice, rats/toxicity reported in guinea pigs ⁵⁸ Chinchillas, guinea pigs, gerbils, mice, rats/toxicity reported in guinea pigs ⁵⁸ Gerbils, hamsters, mice, rats/PD in rats ¹⁴ ; toxicity in hamsters reported ³	
Antibiotics implicated in antibiotic associated clostridial enterotoxemia include: ^{3,4,14,16,25,31,54,58}			
<ul style="list-style-type: none"> Chinchillas: penicillins (including ampicillin, amoxicillin), cephalosporins, clindamycin, erythromycin, lincomycin. Guinea pigs: penicillins (including ampicillin, amoxicillin), cefazolin, clindamycin, erythromycin, lincomycin, dihydrostreptomycin, streptomycin, bacitracin, chlortetracycline, oxytetracycline, tetracycline, tylosin. Hamsters: penicillins (including ampicillin, amoxicillin), cephalosporins, clindamycin, erythromycin, lincomycin, vancomycin, dihydrostreptomycin, streptomycin, bacitracin, oral gentamicin, tylosin. 			
<p>a Antibiotic treatment can result in enteritis and antibiotic-associated clostridial enterotoxemia, especially when antibiotics with a primary gram-positive spectrum are given. Incidence is higher when agents are given orally. Chinchillas, guinea pigs, and hamsters are most susceptible. Also, direct toxicity from streptomycin and dihydrostreptomycin occurs in gerbils, guinea pigs, hamsters, and mice. Procaine, included in some penicillin preparations, can be toxic to mice and guinea pigs. Guinea pigs and chinchillas are highly susceptible to the ototoxic effects of chloramphenicol and aminoglycosides at dosages above those recommended clinically.</p>			

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TABLE 47 Antiparasitic agents used in rodents.

Agent	Dosage	Species/Comments
Albendazole	25 mg/kg PO q12h × 2 days ¹⁹	Chinchillas/giardiasis
Amitraz (Mitaban, Upjohn)	1.4 mL/L topical q7–14d × 3–6 treatments ^{25,49}	Gerbils, hamsters/demodectosis; apply with cottonball, brush; use with caution; not recommended in young
	0.3% solution topically q7d ⁴⁹	Guinea pigs
Carbaryl powder (5%)	Topical q7d × 3 treatments ³	Chinchillas, guinea pigs/ectoparasites
Dichlorvos strip (5 cm long)	Suspend 15 cm above cage × 24 hr, then 2×/wk × 3 wk ³	All species/ectoparasites
Dimetridazole	1 mg/mL drinking water ³	Mice, rats/gastrointestinal protozoa; not available in the United States
Fenbendazole	20 mg/kg PO q24h × 5 days ² 50 mg/kg PO × 5 days ¹⁰ 0.3% feed × 14 days ⁶⁴	All species All species/giardiasis; a lower dose is generally preferred Mice/clinical trial for cestodes, pinworms
Fipronil (Frontline, Merial)	7.5 mg/kg topically q30–60d ⁵⁹	Hamsters, mice, chipmunks/flea adulticide
Imidacloprid (Advantage, Bayer)	½ kitten dose topically ⁴⁹	Prairie dogs
Ivermectin	Spray animals or topical drops, 4–5 times/yr ^{6,25} 0.2–0.4 mg/kg SC q7–14d ^{48,49} 0.5 mg/kg SC, repeat q14d ⁵⁵ 8 mg/L drinking water × 4 days/wk × 5 wk ⁴⁰ 25 mg/L drinking water × 4 days/wk × 5 wk ⁴⁰	Mice/clinical trial for mite control ⁶ ; use 1% ivermectin diluted 1:100 with 1:1 propylene glycol/water (0.1 mg/mL); topical behind ear Chinchillas, guinea pigs, hamsters, prairie dogs, mice, rats/ectoparasites; preferred dosage appears to be 0.4 mg/kg q7d (higher doses have also been reported); for <i>Demodex</i> , use q5–7d Guinea pigs/sarcoptid mites Mice/pinworms Rats/pinworms
Lime sulfur dip	Dip q7d × 6 wk ³	All species/ectoparasites; dilute 1:40 with water
Malathion powder (3%–5%)	Topical 3×/wk × 3 wk ³	Gerbils, hamsters, mice, rats/ectoparasites
Malathion spray/dip	Topical q7d × 3 treatments ³	All species/ectoparasites; use 0.5% spray or 2% dip
Mebendazole	40 mg/kg PO q7d × 21 days ¹	Mice, rats/pinworms
Metronidazole	10–40 mg/animal/day PO ¹ 25 mg/kg PO q12h ⁴⁹ 40 mg/kg PO q24h ⁴⁹ 50 mg/kg PO q12h × 5 days ^{24,49} 70 mg/kg q8h ¹ 2.5 mg/mL drinking water × 5 days ¹	Rats Guinea pigs Prairie dogs Chinchillas/giardiasis; use with caution Hamsters Mice, rats
Permethrin	0.25% dust in cage ⁵ Cotton ball soaked in 5% solution ⁵	All species/ectoparasites Place in cage 4–5 wk

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Piperazine adipate	200 mg/kg PO q24h × 7 days, off 7 days, on 7 days ³	Rats/pinworms	384
	200–600 mg/kg PO q24h × 7 days, off 7 days, on 7 days ³	Gerbils	
	500 mg/kg PO q24h ⁴⁹	Chinchillas	
	0.5 mg/ml drinking water × 21 days ³	Rats/pinworms	
	3–5 mg/ml drinking water × 7 days, off 7 days, on 7 days ⁴⁹	Hamsters	
	4–7 mg/ml drinking water × 3–10 days ⁴⁹	Guinea pigs, mice, rats	
Piperazine citrate	100 mg/kg PO q24h × 2 days ⁴⁹	Chinchillas	385
	2–5 mg/ml drinking water × 7 days, off 7 days, on 7 days ³	All species/pinworms	
	4–5 mg/ml drinking water × 7 days, off 7 days, on 7 days ⁴⁹	Mice, rats, prairie dogs	
	10 mg/ml drinking water × 7 days, off 7 days, on 7 days ⁴⁹	Guinea pigs, hamsters	
Praziquantel (Droncit, Bayer)	6–10 mg/kg PO, ²⁵ SC, ⁴⁹ repeat in 10 days 30 mg/kg PO q14d × 3 treatments ¹⁰	All species/cestodes Gerbils, mice, rats	384
Pyrantel pamoate	50 mg/kg PO ¹	Nematodiasis	385
Pyrethrin powder	Topical 3×/wk × 3 wk ³ Topical q7d × 3 treatments ³	Gerbils, hamsters, mice, rats/ectoparasites Chinchillas, guinea pigs/ectoparasites	385
Pyrethrin (0.05%) shampoo	Shampoo q7d × 4 treatments ⁶³	Hamsters, mice, rats/fleas	
Quinacrine HCl	75 mg/kg q8h ¹	All species/giardiasis in chinchillas	
Selamectin	6 mg/kg topically ⁴⁹	Guinea pigs	
Sulfadimethoxine	10–15 mg/kg PO q12h ²⁵	All species/coccidiosis	385
	25–50 mg/kg PO q24h × 10 days ⁴⁹	Chinchillas, hamsters, guinea pigs/coccidiosis	
	50 mg/kg PO once, then 25 mg/kg q24h × 10–20 days ¹	All species/coccidiosis	
Sulfamerazine	0.8 mg/ml drinking water ³	Gerbils/coccidiosis	385
	1 mg/ml drinking water ³	Chinchillas, hamsters, guinea pigs, mice, rats/coccidiosis	
Sulfamethazine	0.8 mg/ml drinking water ³	Gerbils/coccidiosis	385
	1 mg/ml drinking water ³	Chinchillas, hamsters, guinea pigs, mice, rats/coccidiosis	
	1–5 mg/ml drinking water ¹	All species/coccidiosis	
Sulfaquinoxaline	0.1% in drinking water for 14–21 days ¹	All species/coccidiosis	385
Thiabendazole	50–100 mg/kg PO q24h × 5 days ²	Chinchillas/ascariasis	385
	100 mg/kg PO q24h × 5 days ²	Gerbils, guinea pigs, hamsters, mice, rats	

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TABLE 48 Chemical restraint/anesthetic agents used in rodents.

Agent	Dosage	Species/Comments
Acepromazine	— 0.5–1.0 mg/kg IM ²⁵	See ketamine for combinations Chinchillas, guinea pigs, hamsters, mice, rats/preanesthetic; causes seizures in gerbils
Atipamezole (Antisedan, Pfizer)	— 1 mg/kg SC ⁵⁷ 1.0–2.5 mg/kg IP ¹⁷	Medetomidine reversal Guinea pigs, mice, rats Mice
Atropine	0.05–0.1 mg/kg SC ²⁵ 0.1–0.2 mg/kg SC, IM ⁵ 0.1–0.4 mg/kg SC, IM ^{5,49}	All species/some rats possess serum atropinesterase Chinchillas, guinea pigs Gerbils, hamsters, mice, rats
Diazepam	— 0.5–3.0 mg/kg IM ³ 1–2 mg/kg IM ⁵⁸ 3–5 mg/kg IM ³	See ketamine for combinations Guinea pigs/sedation Guinea pigs/calming effect for intense pruritus or sows apprehensive of young Gerbils, hamsters, mice, rats/sedation
Enflurane (Ethrane, Baxter)	To effect	Guinea pigs/chamber induction; MAC = 2.17% ⁶²
Fentanyl/droperidol (Innovar-Vet, Mallinckrodt)	— 0.06–0.3 ml/kg IM ⁵ 0.1–0.5 ml/kg IM ⁵ 0.13–0.16 ml/kg IM ³ 0.2–0.3 ml/kg IM ³ 0.22–0.88 ml/kg IM ³ 0.3–0.5 ml/kg IM ³	Sedation; anesthesia; dilute 1:10 to reduce chance of inflammation at injection site ³ ; irritation can result in self-mutilation; caution: do not use in gerbils or hamsters Mice/sedation Rats/sedation Rats/sedation Mice/sedation Guinea pigs/sedation; inflammation at injection site at high end of dose range Mice, rats/anesthesia
Fentanyl/fluanisone (Hypnorm, Janssen)	— 0.2–0.5 ml/kg IM ⁵⁶ 0.3–0.6 ml/kg IP ⁵⁶ 0.5–1.0 ml/kg IM ⁵⁶	Anesthesia Mice, rats Mice, rats Guinea pigs
Fentanyl/fluanisone (F)/diazepam (D)	— (F) 0.4 ml/kg IP + (D) 2.5 mg/kg IP ⁵⁷ (F) 0.4 ml/kg IP + (D) 5 mg/kg IP ⁵⁷ (F) 1 ml/kg IM + (D) 2.5 mg/kg IM ⁵⁷	Anesthesia; 45 to 60 min duration Rats Mice Guinea pigs
Fentanyl/fluanisone/midazolam	— 2.7 ml/kg ⁵⁷ IM, IP 8 ml/kg ⁵⁷ IM, IP 10 ml/kg ⁵⁷ IM, IP	Anesthesia; 45 to 60 minute duration; 1 part Hypnorm, 1 part midazolam, 2 parts water Rats Guinea pigs Mice
Glycopyrrolate	0.01–0.02 mg/kg SC ³³	All species/excess oral or respiratory mucus
Halothane	2%–5% induction; 0.25%–3.0% maintenance ^{3,33}	All species
Isoflurane	2%–5% induction; 0.25%–4.0% maintenance ^{3,33}	All species/anesthetic of choice

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Ketamine	— 20–40 mg/kg IM ^{3,49} 22 mg/kg IM ³ 22–44 mg/kg IM ⁴⁹ 40–60 mg/kg IM ³	Ketamine combinations follow Chinchillas, hamsters/light sedation; heavy sedation at higher doses in hamsters (marked individual variation) Mice, rats/light sedation; heavy sedation at 44 mg/kg in mice and 25–40 mg/kg in rats Guinea pigs/light sedation; heavy sedation at higher doses (marked individual variation) Gerbils/light sedation; heavy sedation at higher doses (marked individual variation)	
Ketamine (K)/acepromazine (A)	(K) 40 mg/kg + (A) 0.5 mg/kg IM ^{31,34,46}	Chinchillas/anesthesia	
Ketamine (K)/diazepam (D)	(K) 20–30 mg/kg + (D) 1–2 mg/kg IM ⁵⁴ (K) 20–40 mg/kg + (D) 1–2 mg/kg IM ³¹	Guinea pigs/anesthesia Chinchillas/anesthesia	
Ketamine (K)/medetomidine (M)	(K) 40 mg/kg + (M) 0.5 mg/kg IM, ⁵⁷ IP ³⁶ (K) 50–75 mg/kg + (M) 10 mg/kg IP ¹⁷ (K) 75 mg/kg + (M) 0.5 mg/kg IP ³⁶	Guinea pigs/20–30 min duration of anesthesia Mice/anesthesia; minor procedures; use the higher dose of ketamine in females; (M) reversal is atipamezole Rats, gerbils/surgical anesthesia	387
	(K) 75 mg/kg + (M) 1 mg/kg IP ³⁶ (K) 90 mg/kg + (M) 0.5 mg/kg IP ⁵⁷ (K) 200 mg/kg + (M) 0.5 mg/kg IP ⁵⁷	Mice, hamsters/surgical anesthesia Rats/20–30 min duration Mice/20–30 min duration	388
Ketamine (K)/midazolam (M)	(K) 5–10 mg/kg (M) + 0.5–1.0 mg/kg IM ⁴⁹	Chinchillas, guinea pigs, prairie dogs	
Ketamine (K)/xylazine (X)	(K) 20–40 mg/kg + (X) 2 mg/kg IM ²⁴ (K) 35–40 mg/kg + (X) 4–8 mg/kg IM ³ (K) 50 mg/kg + (X) 2 mg/kg IP ³ (K) 50 mg/kg + (X) 5 mg/kg IP ²⁴ (K) 75–95 mg/kg + (X) 5 mg/kg IM, IP ²⁴ (K) 80 mg/kg + (X) 5 mg/kg IM, IP ²⁴	Guinea pigs/light anesthesia Chinchillas/anesthesia Gerbils/anesthesia Mice/anesthesia Rats/anesthesia Hamsters/anesthesia	
Medetomidine (Dormitor, Pfizer)	— 0.03–0.1 mg/kg SC ³⁶ 0.1 mg/kg SC ³⁶ 0.1–0.2 mg/kg SC ³⁶ 0.3 mg/kg SC ³⁶	See ketamine for combinations Mice, rats/light to moderate sedation Hamsters/light to moderate sedation Gerbils/light to moderate sedation Guinea pigs/variable effects	
Midazolam (Versed, Roche)	1–2 mg/kg IM ²⁵	All species/preanesthetic	
Nalorphine	2–5 mg/kg IV ³	All species/narcotic reversal	
Naloxone (Narcan, Endo Labs)	0.01–0.1 mg/kg SC, IP ³³	All species/narcotic reversal	
Pentobarbital	— 30–45 mg/kg IP ²⁵ 35–40 mg/kg IP ³ 50–90 mg/kg IP ²⁵	Anesthesia; not recommended; marginal analgesia; autonomic depression; give diluted in sterile saline (<10 mg/ml) Guinea pigs, rats Chinchillas Gerbils, hamsters, mice	388
Pipothiazine palmitate	— 25 mg/kg SC ⁴⁵ q5wk	Long-acting neuroleptic drug; antipsychotic (experimental) Rats	389
Propofol (Rapinivet, Mallinckrodt)	— 3–5 mg/kg IV ⁴⁹ 7.5–10.0 mg/kg IV ²² 12–26 mg/kg IV ²²	Anesthesia; induction Prairie dogs Rats Mice	

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Sevoflurane	To effect ⁴⁹	All species/anesthesia
Tiletamine/zolazepam (Telazol, Fort Dodge)	20–40 mg/kg IM ^{20,31,34}	Tiletamine/zolazepam combinations follow Chinchillas, rats/anesthesia
Tiletamine/zolazepam (T)/xylazine (X)	(T) 20 mg/kg + (X) 10 mg/kg IP ³³ (T) 30 mg/kg + (X) 10 mg/kg IM, IP ²⁴	Gerbils/anesthesia Hamsters/anesthesia
Xylazine	—	See ketamine, tiletamine/zolazepam for combinations
Yohimbine (Yobine, Lloyd)	0.5–1.0 mg/kg IV ²⁵	All species/xylazine reversal

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TABLE 49 Analgesics used in rodents.

Agent	Dosage	Species/Comments
Acetaminophen (Tylenol Syrup, McNeil)	1–2 mg/ml drinking water ³³	All
Acetylsalicylic acid (aspirin)	50–100 mg/kg PO q4h ²⁸	Guinea pigs
	80–85 mg/kg PO q4h ³⁶	Guinea pigs
	100 mg/kg PO q48h ³⁶	Rats
	100–150 mg/kg PO q4h ²⁸	Gerbils, hamsters, mice, rats
	100–200 mg/kg PO q6–8h ³⁶	Chinchillas
	120 mg/kg PO q4h ^{36,42}	Mice
	240 mg/kg PO q24h ⁶³	Gerbils, hamsters
Buprenorphine (Buprenex, Reckitt & Colman)	0.01–0.05 mg/kg SC, IV q8–12h ⁵²	Gerbils, hamsters
	0.02–0.5 mg/kg SC, IV, IP q6–12h ²⁵	Rats
	0.05 mg/kg SC q8–12h ²⁵	Chinchillas, guinea pigs
	0.05 mg/kg SC, IM ⁴³	Rats/combine with carprofen (5–10 mg/kg) ⁴³
	0.05–0.1 mg/kg SC q6–12h ⁶³	All species
	0.05–2.5 mg/kg SC, IP q6–12h ²⁵	Mice
	0.1–0.2 mg/kg SC q8h ²⁵	Gerbils
	0.1–0.5 mg/kg SC q8–12h ³⁶	Rats
Butorphanol (Torbugesic, Fort Dodge)	0.5 mg/kg SC q8h ²⁵	Hamsters
	0.2–2.0 mg/kg SC, IP q2–4h ³⁶	Rats, mice
	0.2–2.0 mg/kg SC, IM q4h ^{24,49,52}	Chinchillas
	0.4–2.0 mg/kg SC q4–12h ^{36,49}	Guinea pigs
	1–5 mg/kg SC q4h ^{28,49}	Gerbils, hamsters, mice
Carprofen (Rimadyl, Pfizer)	2 mg/kg SC q2–4h ²⁸	Guinea pigs
	—	Nonsteroidal, antiinflammatory
	1 mg/kg PO q12–24h ⁴⁹	Prairie dogs
	1.5 mg/kg PO q12h ⁵²	Rats
	1–2 mg/kg PO q12–24h ⁴⁹	Guinea pigs
	4 mg/kg SC q24h ⁵⁹	Chinchillas
	4 mg/kg SC q24h ²¹	Guinea pigs
Codeine	5 mg/kg SC q24h ⁵²	Gerbils, hamsters, mice, rats
	5–10 mg/kg PO ⁴³	Rats/can combine with buprenorphine (0.05 mg/kg)
	—	Narcotic
	10–20 mg/kg SC q6h ⁶³	Mice
	60 mg/kg SC q4h ⁶³	Rats
Flunixin meglumine (Banamine, Schering)	—	Nonsteroidal antiinflammatory
	0.3–2.0 mg/kg PO, IM, IV q12–24h ⁵²	Mice
	1.1–2.5 mg/kg SC, IM q12h ⁵²	Rats
	1–2 mg/kg SC ⁵²	Guinea pigs
	1–3 mg/kg SC q12h ³⁰	Chinchillas
	2.5 mg/kg SC q12–24h ²⁸	Gerbils, hamsters, mice, rats
	2.5–5.0 mg/kg SC q12–24h ²⁸	Guinea pigs

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Ibuprofen	— 7–15 mg/kg PO q4h ²⁵ 10 mg/kg PO q4h ²⁵ 10–30 mg/kg PO q4h ^{21,25,38}	Antiinflammatory Mice Guinea pigs Rats
Ketoprofen (Ketofen, Fort Dodge)	1 mg/kg SC, IM q12–24h ⁴⁹ 1–3 mg/kg SC, IM q12–24h ⁴⁹ 5 mg/kg PO, IM q24h ²¹ 5 mg/kg SC ⁵²	Chinchillas, guinea pigs Prairie dogs; doses of 3–5 mg/kg have been used Rats Gerbils, hamsters, rats
Meloxicam (Metacam, Boehringer Ingelheim Vetmedica)	— 1–2 mg/kg PO, SC ²¹	Nonsteroidal antiinflammatory Mice, rats
Meperidine (Demerol, Winthrop-Breon)	10–20 mg/kg SC, IM q2–3h ²¹ 20 mg/kg SC, IM q2–3h ²⁸	Guinea pigs, mice, rats Gerbils, guinea pigs, hamsters, mice, rats
Morphine	— 2–5 mg/kg SC q2–4h ²⁸ 2–5 mg/kg SC, IM q4h ²⁸ 10 mg/kg SC, IM q4h ⁶³	Narcotic Gerbils, hamsters, mice, rats Guinea pigs Guinea pigs
Nalbuphine (Nubain, Endo Labs)	1–2 mg/kg IM q3h ²⁸ 4–8 mg/kg IM q3h ²⁸	Guinea pigs Gerbils, hamsters, mice, rats
Oxymorphone	— 0.2–0.5 mg/kg SC, IM q6–12h ²⁸	Narcotic Gerbils, guinea pigs, hamsters, mice, rats
Pentazocine (Talwin, Sanofi Winthrop)	10 mg/kg SC q2–4h ²⁸	Gerbils, guinea pigs, hamsters, mice, rats
Piroxicam (Feldene, Pfizer)	— 3.4–20.0 mg/kg PO ⁶⁷	Nonsteroidal antiinflammatory Mice

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TABLE 50 Emergency drugs used in rodents.

Agent	Dosage	Species/Comments
Atropine	0.05–0.1 mg/kg SC ²⁵	All species/bradycardia; some rats possess serum atropinase
	0.1–0.2 mg/kg SC, IM ³	Chinchillas, guinea pigs
	0.4 mg/kg SC, IM ³	Gerbils, hamsters, mice, rats
	10 mg/kg SC q20 min ¹	All species/organophosphate overdose
Calcium gluconate	100 mg/kg IP ⁵⁹	Chinchillas/hypocalcemic tetany; eclampsia
	100 mg/kg IM ²⁹	Guinea pigs/dystocia; follow with 1 IU oxytocin (see Table 51)
Dexamethasone	—	All species/antiinflammatory
	0.6 mg/kg IM ¹	Guinea pigs/pregnancy toxemia
	4–5 mg/kg SC, IM, IP, IV ⁴⁸	All species/shock
Diazepam	1–2 mg/kg IM ⁵⁸	Guinea pigs/calming effect for intense pruritus
	1–5 mg/kg IM, IV, IP, IO ⁴⁸	All/treatment of seizures
Diphenhydramine (Benadryl, Parke-Davis)	5 mg/kg SC ⁴¹	Antihistamine; anaphylaxis Guinea pigs
Dopamine	0.08 mg/kg IV ⁴¹	Guinea pigs/hypotension
Doxapram	—	Respiratory stimulant
	2–5 mg/kg IV, IP ²⁴	Guinea pigs
	5–10 mg/kg IV, IP ²⁴	Chinchillas, gerbils, hamsters, mice, rats
Ephedrine (Marax, Pfizer)	1 mg/kg IV ⁴¹	Guinea pigs/antihistamine; stimulant
Epinephrine	0.003 mg/kg IV ⁴¹	Guinea pigs/cardiac arrest
Furosemide	—	Diuretic for edema, pulmonary congestion, ascites
	1–4 mg/kg SC, IM q4–6h ²⁶	All species
	5–10 mg/kg SC, IM q12h ²⁶	All species
Glycopyrrolate	0.01–0.02 mg/kg SC ³³	All species/bradycardia
Lactated Ringer's solution	10–25 mL/kg IV ⁵¹	Give slowly over 5–10 min (if unsuccessful, administer IP)
Vitamin C (ascorbic acid)	50 mg/kg SC, IM ⁶³	Guinea pigs/ascorbic acid deficiency (scurvy)

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TABLE 51 Miscellaneous agents used in rodents.

Agent	Dosage	Species/Comments
Aluminum hydroxide	20–40 mg/animal PO prn ⁶³	Hyperphosphatemia caused by renal failure
Aminophylline	50 mg/kg ¹	Guinea pigs
Atropine	0.05–0.1 mg/kg ¹ IM, SC 10 mg/kg SC q20min ²⁵	All species/preanesthetic All species/organophosphate toxicity; may cause cardiovascular irregularities in guinea pigs
Atropine (1%)/phenylephrine (10%)	Topical to eyes ²⁵	All species/mydriasis for nonalbino eyes
Calcium EDTA	25 mg/kg SC q6–12h ⁴⁹ 30 mg/kg SC q12h ^{31,49}	Prairie dogs/lead chelation Chinchillas, guinea pigs/lead chelation
Chlorpheniramine maleate	0.6 mg/kg PO q24h ¹	Guinea pigs/antihistamine
Cimetidine (Tagamet, SmithKline Beecham)	5–10 mg/kg PO, SC, IM, IV q6h–q12h ²	All species/gastric, duodenal ulceration; esophagitis, gastroesophageal reflux
Cisapride (Propulsid, Janssen)	0.1–0.5 mg/kg PO q12h ⁴⁸ 0.5 mg/kg PO q8–12h ⁴⁹	All species/enhance gastrointestinal motility; not commercially available in the United States Chinchillas, guinea pigs
Cyclophosphamide	300 mg/kg IP q24h ⁴¹	Guinea pigs/antineoplastic
Dexamethasone	— 0.5–2.0 mg/kg PO, SC, then decreasing dose q12h × 3–14 days ²⁵ 0.6 mg/kg IM ³	Antiinflammatory All species All species
Digoxin	0.05–0.1 mg/kg PO q12–24h ⁴⁸	Hamsters/dilated cardiomyopathy
Diphenhydramine (Benadryl, Parke-Davis)	— 1–2 mg/kg PO, SC q12h ⁴⁹ 5 mg/kg SC prn ⁴¹ 7.5 mg/kg PO ¹	Antihistamine; anaphylaxis Chinchillas, hamsters, mice, rats Guinea pigs Guinea pigs
Dopamine	0.08 mg/kg IV prn ⁴¹	Guinea pigs/hypotension, especially anesthetic related
Ephedrine (Marax, Pfizer)	1 mg/kg PO, IV prn ⁴¹	Guinea pigs/antihistamine; anaphylaxis
Epinephrine	0.003 mg/kg IV prn ⁴¹	Guinea pigs/cardiac arrest
Furosemide	— 1–4 mg/kg IM q4–6h ²⁶ 2–5 mg/kg PO, SC q12h ⁴⁹ 2–10 mg/kg PO, SC q12h ⁴⁹ 5–10 mg/kg SC, IM q12h ²	Diuretic for pulmonary congestion, edema, ascites All species Chinchillas, guinea pigs Hamsters, mice, rats All species
Heparin	5 mg/kg IV prn ⁴¹	Guinea pigs/disseminated intravascular coagulation
Human chorionic gonadotropin (hCG)	1000 USP units/animal IM, repeat in 7–10 days ⁵⁴	Guinea pigs/cystic ovaries
Hydralazine	1 mg/kg IV prn ⁴¹	Guinea pigs/antihistamine
Insulin	2 U/animal SC ⁴¹	Hamsters
Kaolin pectin	0.2 ml PO q6–8h ¹	Guinea pigs/antidiarrheal
Lactated Ringer's solution	10–25 ml/kg IV bolus over 5–10 min ¹ 50–100 ml/kg SC, IV, IO q24h ⁵¹	Warm to 37° C All species/maintenance fluid requirements

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Lactobacilli	—	All species/PO during antibiotic treatment period, then 5–7 days beyond cessation ¹⁶ ; give 2 hr before or 2 hr after antibiotic treatment ¹⁶	
Loperamide HCl (Imodium A-D, McNeil)	0.1 mg/kg PO q8h × 3 days, then q24h × 2 days ²⁵	All species/enteropathies (diarrhea); give in 1 ml water	
Leuprolide acetate depot (Lupron Depot, TAP Pharmaceuticals)	0.2–0.3 mg/kg IM q28d ⁵⁰	Guinea pigs/cystic ovaries	
Metoclopramide (Reglan, Robins)	0.2–1.0 mg/kg PO, SC, IM q12h ⁴⁸	All species/gastric stasis	
Neomycin/dexamethasone/polymyxin B ophthalmic (Maxitrol, Alcon)	Topical to eyes q8–12h ⁴⁸	All species/ophthalmic preparation; may cause gastrointestinal stasis from steroids	
Oxytocin	0.2–3.0 IU/kg SC, IM, IV ³	All species/delayed parturition if unobstructed; caution in guinea pigs: fusion of pubic symphysis occurs if first breeding does not occur before 6–9 mo of age, resulting in dystocia; if no young produced 15 min after 1 IU/animal, cesarean section is indicated	395
	1 IU/kg SC, IM ¹ 1–2 IU/animal IM ¹ 6.25 IU/kg SC ¹	Rats Guinea pigs/uterine contraction; milk letdown Mice/milk letdown	396
Phenobarbital	10–20 mg/kg IV, IP ⁴¹	Guinea pigs/seizures	
Potassium citrate	10–30 mg/kg PO q12h ⁴⁹	Guinea pigs	
Prednisone	0.5–2.2 mg/kg PO, SC, IM ^{3,49}	All species/antiinflammatory	
Pseudoephedrine (Robitussin, Robins)	1.2 mg/animal PO q12h ⁵⁹	Chinchillas/antihistamine	
Sucralfate (Carafate, Hoechst Marion Roussel)	25–50 mg/kg PO ⁴⁹ 50 mg/kg PO ²⁶	All species/oral, esophageal, gastric, and duodenal ulcers All species	
Theophylline	10 mg/kg PO q8–12h ⁴⁹	Prairie dogs	
Tropicamide (1%)	Topical to eyes ²⁵	All species/mydriasis in albino eyes	
Vitamin A	50–500 IU/kg IM ⁴¹ 10 mg x-carotene/kg of feed ¹ 2 µg vitamin A palmitate/g food ¹	Guinea pigs, hamsters Guinea pigs Hamsters	
Vitamin B complex (small animal)	0.02–0.2 ml/kg SC, IM ^{3,61}	All species/B ₁ (100 mg/ml), B ₂ (2 mg/ml), B ₁₂ (0.1 mg/ml)	
Vitamin C (ascorbic acid)	10–30 mg/kg PO, SC, IM ¹ 20–200 mg/kg SC, IM ² 50–100 mg/animal PO, SC daily ⁵⁴ 0.2–0.4 mg/ml drinking water ⁵⁴	Guinea pigs/maintenance Guinea pigs/treatment of deficiency Guinea pigs/treatment of deficiency; start parenteral, then PO until resolution of clinical signs Guinea pigs/prevents deficiency; change daily	
Vitamin D	200–400 IU/kg SC, IM ³	All species	
Vitamin E/selenium (Bo-Se, Schering)	0.1 ml/100–250 g SC ³	All species	
Vitamin K ₁	1–10 mg/kg IM q24h × 4–6 days ²⁵ 2.5–5.0 mg/kg IM q24h × 21–28 days ²⁵	All species/warfarin poisoning; menadiols not used in acute cases All species/brodifacoum poisoning; menadiols not used in acute cases	396

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APPENDIX 60 Common and scientific names of rodents.⁵⁷

Common Name	Other Common Names	Scientific Name
Chinchilla	Long-tailed chinchilla	<i>Chinchilla laniger</i>
Chipmunk	Siberian chipmunk; Korean chipmunk; Japanese squirrel	<i>Tamias sibericus (Eutamias sibericus)</i>
Degu	Common degu	<i>Octodon degus</i>
Duprasi	Fat-tailed gerbil	<i>Pachyuromys duprasi</i>
Gerbil	Mongolian gerbil; clawed jird	<i>Meriones unguiculatus</i>
Guinea pig	Cavy	<i>Cavia porcellus</i>
Hamster, Chinese	Striped hamster	<i>Cricetulus griseus</i>
Hamster, dwarf	Russian dwarf hamster	<i>Phodopus sungorus sungorus</i>
Hamster, golden	Syrian hamster; common hamster	<i>Mesocricetus auratus</i>
Jird	Shaw's jird	<i>Meriones shawii</i>
Mouse	Common mouse	<i>Mus musculus</i>
Prairie dog	Black-tailed prairie dog	<i>Cynomys ludovicianus</i>
Rat	Brown rat	<i>Rattus norvegicus</i>

APPENDIX 61 Hematologic and serum biochemical values of rodents.^{3,15,65}

Measurement	Mouse	Rat	Gerbil	Hamster	Guinea Pig	Chinchilla	Prairie Dog
PCV (%)	35–40	35–45	35–45	45–50	35–45	27–54	36–54
RBC ($10^6/\mu\text{l}$)	7–11	7–10	7–8	7–8	4–7	5.6–8.4	5.9–9.4
Hb (g/dl)	10–20	12–18	14–16	16.6–18.6	11–17	11.8–14.6	12.7–19.6
WBC ($10^3/\mu\text{l}$)	4–12	5–23	7.5–10.9	7–10	7–14	5.4–15.6	1.9–10.1
Neutrophils (%)	5–40	10–50	22	18–40	20–60	39–54	43–87
Lymphocytes (%)	30–90	50–70	75	56–80	30–80	45–60	8–54
Monocytes (%)	0–10	0–10	0–4	2	2–20	0–5	0–12
Eosinophils (%)	0–5	0–5	0–3	0–1	0–5	0–5	0–10
Basophils (%)	0–1	0–1	0–1	0–1	0–1	0–1	0–2
ALT (IU/L)	26–77	20–92	—	22–128	10–25	10–35	26–91
AP (IU/L)	45–222	16–96	—	99–186	—	6–72	25–64
AST (IU/L)	54–269	—	—	28–122	—	96	16–53
Bilirubin, total (mg/dl)	0.1–0.9	0.2–0.6	0.2–0.6	0.1–0.9	0.3–0.9	0.6–1.3	0.1–0.3
Calcium (mg/dl)	3.2–8.0	5.3–13.0	3.7–6.2	5.3–12	7.8–10.5	5.6–12.1	8.3–10.8
Chloride (mEq/L)	82–114	—	—	—	98–115	108–129	—
Cholesterol (mg/dl)	26–82	40–130	90–150	55–181	20–43	50–302	—
Creatinine (mg/dl)	0.3–1.0	0.2–0.8	0.6–1.4	0.4–1.0	0.6–2.2	0.4–1.3	0.8–2.3
Glucose (mg/dl)	62–175	50–135	50–135	37–198	60–125	109–193	120–209
Phosphorus (mg/dl)	6.0–10.4	5.8–8.2	3.7–7.0	3.0–9.9	5.3	4–8	3.6–10.0
Potassium (mEq/L)	5.1–10.4	5.9	3.3–6.3	3.9–5.5	6.8–8.9	3.3–5.7	4.0–5.7
Protein, total (g/dl)	3.5–7.2	5.6–7.6	4.3–12.5	5.2–7.0	4.6–6.2	3.8–5.6	5.8–8.1
Albumin (g/dl)	2.5–4.8	3.8–4.8	1.8–5.5	3.5–4.9	2.1–3.9	2.3–4.1	2.4–3.9
Globulin (g/dl)	0.6	1.8–3.0	1.2–6.0	2.7–4.2	1.7–2.6	0.9–2.2	3.4–4.2
Sodium (mEq/L)	112–193	135–155	141–172	128–144	146–152	142–166	144–175
Triglycerides (mg/dl)	—	26–145	—	72–227	0–145	—	—
Urea nitrogen (mg/dl)	17–28	15–21	17–27	12–26	9–32	17–45	21–44

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APPENDIX 62 Biologic and physiologic data of rodents.^{2,3,25,39,65}

Species	Avg Wt (g) (male/female)	Avg at Puberty (days) (male/female)	Life Span (yr)	Temperature °C (°F)	Heart Rate (beats/min)	Respiratory Rate (breaths/min)
Chinchilla	450–600/550–800	240–540/240–540 ^a	8–10	36.1–37.8 (97.0–100.0)	40–100	40–80
Degu	200–300	90–180	10 (record)	—	—	—
Duprasi	60–90	75–105	3	—	—	—
Gerbil	65–100/55–85	70–85/65–85	3–4	37.0–38.5 (98.6–101.3)	360	90
Guinea pig	900–1200/700–900	90–120/60–90	4–5	37.2–39.5 (99.0–103.1)	230–380	40–100
Hamster	85–130/95–150	70–100/40–70	1.5–2.0	37.0–38.0 (98.6–100.4)	250–500	35–135
Mouse	20–40/25–40	50/50–60	1.5–3.0	36.5–38.0 (97.5–100.4)	325–780	60–220
Prairie dog	1000–2200/500–1500	730–995	6–10	35.4–39.1 (95.7–102.3)	83–318	40–60
Rat	450–520/250–300	65–110	2.5–3.5	35.9–37.5 (96.6–99.5)	250–450	115

^a Babies born in fall breed 1 yr later.

APPENDIX 63 Blood volumes of rodents with safe bleeding volume recommendations.²⁷

Species	Blood Volume (Average)	Safe Venipuncture Volume
Gerbil	67 ml/kg	0.3 ml/animal
Guinea pig	75 ml/kg	7.7 ml/kg
Hamster	78 ml/kg	5.5 ml/kg
Mouse	79 ml/kg	7.7 ml/kg
Rat	64 ml/kg	5.5 ml/kg

APPENDIX 64 Urinalysis reference values for gerbils, hamsters, mice, and rats.^{a,7}

Measurement	Gerbil	Hamster	Mouse	Rat
Urine volume (ml/24 hr)	2–4 drops	5.1–8.4	0.5–2.5	13–23
Specific gravity	—	1.060	1.034	1.022–1.050
Average pH	—	8.5	5.01	5–7
Protein (mg/dl)	—	—	Males proteinuric	<30

^a Ranges should be considered as guides; values are likely to vary between groups of animals according to such variables as strain, age, sex, fasting, and methodology.

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APPENDIX 65 Reproductive data for rodents. ^{2,3,25,39,65}

Species	Estrus Length (days)	Gestation (days)	Litter Size	Birth Weight (g)	Age Eyes Open (days)	Weaning Age (days)
Chinchilla	30–50	105–115	2–3	30–50	Birth	36–48
Degu	—	87–93	1–10	14	2–3	28
Duprasi	—	19–22	3–6	—	—	21–28
Gerbil	4–6	24–26	4–6	2.5–3.5	16–20	20–30
Guinea pig	15–17	59–72	2–5	60–100	Birth	14–28
Hamster	4	15–18	4–12	2	14–16	20–28
Mouse	4–5	19–21	10–12	0.5–1.5	10–14	21–28
Prairie dog	14–21	30	2–10	—	—	42–49
Rat	4–5	19–23	6–12	5–6	12–17	17–21

APPENDIX 66 Determining the sex of mature rodents. ²⁸

Male	Female
<ul style="list-style-type: none"> Anogenital distance is longer in the male. Manipulate “genital papilla” (prepuce) to protrude penis. Palpate for testicles either in a scrotal sac (if present) or subcutaneous in inguinal region. Males have only two external openings in the inguinal area: <ul style="list-style-type: none"> anus urethral orifice at tip of penis/(1) <p>In very fat males, there may be a depression between the penis and anus. This depression can be obliterated by manipulating the skin in that area.</p>	<ul style="list-style-type: none"> Anogenital distance is shorter in the female. Look for three external openings in the inguinal area: <ul style="list-style-type: none"> anus (most caudal opening) vaginal orifice (middle opening, look carefully) urethral orifice at tip of urethral papilla (most cranial opening)/(1) <p>The urethral papilla is located outside the vagina (unlike dogs and cats).</p> <p>In very fat females or young females, the vaginal orifice may be either hidden by folds of skin (the former) or sealed (latter). Gentle manipulation of the skin in this area will divulge the orifice.</p>

APPENDIX 67 Nutritional data for rodents. ^{3,25,65}

Consumption (per 100 g BW/day)			Nutritional Recommendations			
Species	Food (g)	Water (ml)	Minimum Fiber (%)	Carbohydrates (%)	Fat (%)	Protein (%)
Chinchilla	3–6	—	—	—	—	—
Gerbil	5–8	4–7	—	—	2–4	16–22
Guinea pig	6	10	16–18	16	—	18–30
Hamster	8–12	8–10	—	8	3–5	15–25
Mouse	12–18	15	—	45–55	5–25	16–20
Prairie dog	2.3–4.1	—	—	—	—	—
Rat	5–6	≥10–12	—	—	5–25	12–27

APPENDIX 68 Zoonotic diseases in rodents.

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Species	Potential Zoonotic Disease
Chinchilla ³⁹	<i>Listeria monocytogenes</i> Lymphocytic choriomeningitis (LCM); rare Dermatophytes (<i>Trichophyton mentagrophytes</i> , <i>Microsporum canis</i> , <i>M. gypseum</i>) <i>Baylisascaris procyonis</i>
Gerbil ²⁵	Salmonellosis; rare <i>Hymenolepis nana</i> ; rare
Guinea pig ^{25,35}	Allergies (cutaneous and respiratory) to dander and urinary proteins <i>Bordetella</i> , salmonellosis, <i>Yersinia pseudotuberculosis</i> , <i>Streptococcus</i> ; rare Dermatophyte (<i>Trichophyton mentagrophytes</i>) Sarcoptic mites (<i>Trixacarus caviae</i> , <i>Sarcoptic scabei</i>)
Hamster ^{13,25}	Salmonellosis, <i>Acinetobacter</i> Lymphocytic choriomeningitis (LCM); rare Dermatophytes (<i>Trichophyton mentagrophytes</i> , <i>Microsporum</i> spp.) <i>Hymenolepis nana</i>
Mouse ²⁵	Allergies (cutaneous and respiratory) to dander and urinary proteins Salmonellosis; rare Lymphocytic choriomeningitis (LCM); rare
Prairie dog ³⁹	<i>Clostridium piliformes</i> , <i>Pasteurella multocida</i> , salmonellosis, <i>Yersinia pseudotuberculosis</i> , <i>Y. pestis</i> , <i>Y. enterocolitica</i> Hanta virus (wild caught), rabies virus (wild caught) Dermatophytes (<i>Trichophyton mentagrophytes</i> , <i>Microsporum gypseum</i>) Various ectoparasites (mites, fleas, lice)
Rat ²⁵	Allergies (cutaneous and respiratory) to dander and urinary proteins Leptospirosis, salmonellosis, cestodiasis, streptococcal infection Hemorrhagic fever, sylvatic plague (vector: rat fleas), St Louis encephalitis (vector: <i>Liponyssus sylviarum</i>), rat bite fever (<i>Streptobacillus moniliformis</i>)

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7.1 APPENDIX 69 Literature cited-rodents.

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Rabbits

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TABLE 52 Antimicrobial and antifungal agents used in rabbits.^a

Agent	Dosage	Comments
Alatrofloxacin (Trovan, Pfizer)	15 mg/kg IV (single dose) ⁹²	Bacterial meningitis
Amikacin	2 mg/kg SC, IM, IV q8h ⁵⁰ 2–5 mg/kg SC, IM q8–12h ³⁷ 10 mg/kg SC, IM q8–12h ² 1.25 g/20 g methylmethacrylate ⁷	Place in bone after surgical debridement of jaw abscess
Amphotericin B	—	Severe fungal infections; use in combination with fluconazole ⁹⁵ ; potentially nephrotoxic and hepatotoxic
• Desoxycholate	1 mg/kg IV q24h ⁹⁵	Invasive aspergillosis
• Liposomal	5 mg/kg IV q24h ⁸⁶	
Cefazolin	2 g/20 g methylmethacrylate ⁷	Place in bone after surgical debridement of jaw abscess
Ceftazidime	50 mg/kg IM, IV q3h ¹	Publication details drug half-life, not dosing frequency
Ceftiofur (Ceftiofur, Pharmacia & Upjohn)	2 g/20 g methylmethacrylate ⁷	Place in bone after surgical debridement of jaw abscess
Ceftriaxone (Rocephin, Roche)	40 mg/kg IM q12h × 2 days ⁹⁵	Bacterial infections; rabbit syphilis ⁵⁶
Cephalexin	11–22 mg/kg PO q8h ⁸⁷ 15 mg/kg SC q12h ³⁵	
Cephaloridine	10–25 mg/kg SC, IM q24h × 5 days ⁴⁰ 11–15 mg/kg IM q12h ⁷	
Cephalothin	12.5 mg/kg q6h × 6 days ⁸⁷ 2 g/20 g methylmethacrylate ⁷	Place in bone after surgical debridement of jaw abscess
Chloramphenicol	25 mg/kg PO q8–12h ⁸⁷ 30 mg/kg PO q12h ⁵⁰ 30 mg/kg SC, IM, IV q8–12h ^{50,87} 50 mg/kg PO, SC, IM, IV q8h ⁴⁴ 1.3 mg/ml drinking water ¹⁴	Partially effective at 0.5 mg/ml in clinical trial for pasteurellosis ⁷⁷
Chlortetracycline	50 mg/kg PO q24h ¹⁴	
Ciprofloxacin (Cipro, Bayer; Ciloxan, Alcon)	5–20 mg/kg PO q12h ⁸⁷ 10–20 mg/kg PO q12h ⁴⁴ 1 drop topical q8–12h ³⁴ 2 drops topical q1h for 7–14 hr ⁸²	Suspension in water, stable for 14 days ⁸⁷ ; may cause arthropathies in young ⁹⁸ Nasal pasteurellosis; maintains therapeutic levels in tear film for at least 6 hr after application (tears drain into nasal sinus) Ocular penetration injuries, good penetration into aqueous and vitreous humor
Clotrimazole (Lotrimin, Schering)	Topical ³⁹	Localized dermatophytosis
Doxycycline	2.5 mg/kg PO q12h ¹⁸ 4 mg/kg PO q24h ⁷⁶	

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Enrofloxacin (Baytril, Bayer)	—	May cause arthropathies in young ⁹⁸ ; limit SC and IM injections (may cause muscle necrosis or sterile abscesses) PD ^{11,15} ; clinical trial for pasteurellosis, × 14 days ¹⁰ Licensed for use in rabbits in some countries 14–30 days for pasteurellosis ⁸⁷ Clinical trial for pasteurellosis; successful when intake >5 mg/kg q24h ⁷⁷ Clinical trial for pasteurellosis, × 14 days ¹⁰
	5 mg/kg PO, SC, IM, IV q12h ^{10,11,15}	
	5–10 mg/kg PO, SC, IM q12h ¹⁸	
	5–20 mg/kg PO, IM q12h ⁸⁷	
	100 mg/L drinking water ⁷⁰	
	200 mg/L drinking water ¹⁰	
Fluconazole	25–43 mg/kg IV (slow) q12h ⁶¹	Systemic fungal disease
Furazolidone	5 mg/kg PO q24h × 14 days ¹⁴ 5.5 g/L drinking water ¹⁴ 50 mg/kg feed ¹⁴	
Fusidic ointment (Fuciderm, Leo)	Topical to skin q12–24h ³⁵	Superficial pyoderma
Gentamicin	1.5–2.5 mg/kg SC, IM, IV q8h ⁸⁷ 2.5 mg/kg SC, IM, IV q8–12h ⁴⁴ 4 mg/kg SC, IM q24h ¹⁴ 1 g/20 g methylmethacrylate ⁷	Seldom indicated; use with caution Place in bone after surgical debridement of jaw abscess
Griseofulvin	12.5 mg/kg PO q12h × 30–45 days ^{51,87} 25 mg/kg PO q24h × 30–45 days ⁵¹	Advanced cases of dermatophytosis; decrease dose by 50% with ultramicrosize form (Gris-PEG, Allergan Herbert), which has better absorption
Ketoconazole	10–40 mg/kg PO q24h × 14 days ³⁷	Dermatophytosis
Lime sulfur (2%–3%)	Topical q5–7d × 4 wk ⁸⁷	Dermatophytosis; use with caution
Metronidazole	20 mg/kg PO q12h ^{18,44} 40 mg/kg PO q24h × 3 days ¹⁴	
Micafungin	0.25–2.0 mg/kg IV q24h ⁸⁶	Systemic candidiasis
Miconazole (Conofite, Schering-Plough)	Topical q24h × 14–28 days ³⁷	Localized dermatophytosis
Moxifloxacin	40 mg/kg IV q12–24h ⁸⁰ (suggested frequency)	Bacterial meningitis
Neomycin	30 mg/kg PO q12h ¹⁴ 200–800 mg/L drinking water ⁷⁶	
Netilmicin (Netromycin, Schering)	6–8 mg/kg SC, IM, IV ¹⁰⁰ q24h	Dilute and give over 20 min for IV use; gram-negative infections
Nitrofurazone	8–11 mg/kg PO q12h ³³	
Ofloxacin (Ocuflox, Allergan)	20 mg/kg SC q8h ⁶²	Urogenital, skin, respiratory infections
Oxytetracycline	15 mg/kg IM q8h ⁶⁴ 25 mg/kg SC q24h ⁷⁶ 50 mg/kg PO q12h ¹⁴ 1 mg/ml drinking water ¹⁴	PD; anorexia and diarrhea at 30 mg/kg IM q8h; tissue irritation can occur
Penicillin	40,000–60,000 IU/kg IM q12h × 5–7 days ⁵¹	Rabbit syphilis
Penicillin G, benzathine	42,000–60,000 IU/kg IM q48h ³³ 42,000–84,000 IU/kg SC q7d × 3 wk ⁸⁷	Rabbit syphilis
Penicillin G, procaine	40,000 IU/kg IM q24h × 5–7 days ²⁹	Rabbit syphilis

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	42,000–84,000 IU/kg SC, IM q24h ³³ 60,000 IU/kg IM q8h ¹¹²	PD PD	414
Rifampin (R)/azithromycin (A)	(R) 40 mg/kg PO q12h + (A) 50 mg/kg PO q24h ⁹⁹	<i>Staphylococcus osteomyelitis</i>	
Rifampin (R)/clarithromycin (C)	(R) 40 mg/kg + (C) 80 mg/kg PO q12h ⁹⁹	<i>Staphylococcus osteomyelitis</i>	
Silver sulfadiazine cream (Silvadene cream, Marion)	Topical q24h ⁵¹	Does not cause diarrhea if ingested	
Sulfadimethoxine	10–15 mg/kg PO q12h ²¹		
Sulfamethazine	1 mg/ml drinking water ¹⁴ 5–10 g/kg feed ¹⁴		
Sulfaquinoxaline	1 mg/ml drinking water ¹⁴ 0.6 g/kg feed ¹⁴		
Tetracycline	50 mg/kg PO q8–12h ¹⁴ 50–100 mg/kg PO q8h ⁸⁷ 250–1,000 mg/L drinking water ³³	Therapeutic levels not achieved even at 800–1600 mg/L ⁸⁵ ; 250 mg/L not effective in clinical trial for pasteurellosis ⁷⁷	
Thiamphenicol	30 mg/kg PO, IM, IV q6h ²⁸	Derivative of chloramphenicol; reference describes pharmacokinetics of single dose ²⁸ ; not available in the United States	
Tilmicosin (Micotil, Elanco)	25 mg/kg SC once ⁶⁵	Pasteurellosis; use cautiously: at least one rabbit death and several human deaths have been reported ¹⁷ ; has been associated with anemia and leucopenia	
Tobramycin (Nebcin, Lilly)	1 g/20 g methylmethacrylate ¹¹ 10% in calcium sulfate pellets ⁷²	Place in bone after surgical debridement of jaw abscess Biodegradable implants for treatment of osteomyelitis	
Trimethoprim/sulfa	15 mg/kg PO q12h ¹⁴ 30 mg/kg PO, SC, IM q12h ^{37,50,87} 30 mg/kg SC q24h ¹⁴ 48 mg/kg SC q12h ³⁵	May cause tissue necrosis SC; do not use SC ³⁷ May cause tissue necrosis May cause tissue necrosis	414
Tylosin (Tylan, Elanco)	10 mg/kg PO, SC, IM q12h ¹⁴ 10 mg/kg PO, SC, IM q24h ²²		415
Vancomycin	10 mg vancomycin and 50 mg copolymer 50:50 poly (DL-lactide)/co-glycolide, moulded into 8 mm beads and compressed at 55° C ¹⁰⁹	Osteomyelitis, effective locally for 56 days	
a There is a potential for antibiotic-induced enterotoxemia after administration of some antimicrobial agents (see Appendix 76). Appetite and fecal character must be monitored closely during and after therapy.			415

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TABLE 53 Antiparasitic agents used in rabbits.

Agent	Dosage	Comments
Albendazole	7.5–20 mg/kg PO q24h ¹³ × 3–14 days ³⁵	Potential treatment for encephalitozoonosis
Amprolium (9.6%)	0.5 ml/pint drinking water × 10 days ^{37,44} 5 ml/gal drinking water × 21 days ⁸⁷	Coccidiosis
Carbaryl powder (5%)	Topical q7d ⁷¹ Topical, apply weekly ⁷¹	Ectoparasites; use sparingly
Decoquinate (Deccox, Rhone-Poulenc)	62.5 ppm in feed ³⁷	Coccidiosis
Diclazuril	1 ppm in feed ³⁷	Coccidiosis
Dimetridazole	0.2 mg/ml drinking water ¹⁴	Not available in the United States
Fenbendazole	5 mg/kg PO ⁷⁶ 10 mg/kg PO, repeat in 14 days prn ⁴⁴ 20 mg/kg PO q24h for 7 days before and 2 days after mixing rabbits ¹⁰⁴ 20 mg/kg PO q24h × 28 days ¹⁰⁴ 50 ppm in feed × 2–6 wk ⁷⁶	Preventative against encephalitozoonosis Treatment for encephalitozoonosis; failed to clear all parasites
Fipronil (Frontline, Merial)	Contraindicated ⁶⁹	May cause neurologic disease and death
Imidacloprid (Advantage, Bayer)	Use cat dose; place in 2–3 areas along dorsum q30d ³¹ 10–16 mg/kg (single 0.4 ml dose, 10% solution) as a single topical application ^{35,47}	Flea adulticide Flea adulticide
Ivermectin	— 0.1–0.2 mg/kg SC, repeat in 14 days ⁹ 0.2–0.4 mg/kg SC q10–14d ⁷¹ 0.4 mg/kg PO, SC q7–14d ⁴⁴ 0.4 mg/kg SC q7d × 2–3 wk ⁸⁷ 0.6 mg/kg SC q14d ⁶⁹	Ectoparasites Ear mites, clinical trial
Lasalocid	120 ppm in feed ³⁷	Coccidiosis
Lime sulfur (2%–3%)	1–2 dips/wk × 28 days ⁸⁷ Dip q7d × 4–6 wk ^{71,87}	Ectoparasites; young animals
Lufenuron (Program, Novartis)	30 mg/kg PO q30d ⁶⁹	Flea larvicide
Monensin (CoBan 60, Elanco)	0.002%–0.004% in feed ³⁷	Coccidiosis
Moxidectin	0.2 mg/kg PO, repeat in 10 days ¹¹⁰	Psoroptic mange; small animal formulation is not currently available in the United States
Piperazine	200 mg/kg PO, repeat in 14–21 days ^{44,87} 500 mg/kg PO × 2 days ⁵⁷ 750 mg/kg PO × 2 days ⁵⁷ 2–5 mg/ml drinking water × 7 days ⁴⁴	Use with citrate formulation Adults/use with adipate formulation Young
Praziquantel (Droncit, Bayer)	5–10 mg/kg PO, SC, IM, repeat in 10 days ²	
Pyrantel pamoate	5–10 mg/kg PO, SC, IM, repeat in 10 days ⁷¹ 5–10 mg/kg PO, repeat in 14–21 days ⁸⁷	
Pyrethrins	Topically as directed for puppies/kittens q7d ^{69,71}	Flea control
Rofenaid (Rofenaid 40, Roche)	62.5–250 ppm in feed ³⁷	Coccidiosis

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Selamectin (Revolution, Pfizer)	6–10 mg/kg topically ^{17,71}	Ectoparasites (e.g., ear mites, fleas)	
Sulfadimethoxine	50 mg/kg PO once, then 25 mg/kg q24h × 10–20 days ^{37,44}	Coccidiosis	
Sulfadimidene	100–233 mg/L drinking water ³⁵	Coccidiosis	
Sulfamerazine	100 mg/kg PO ³³ 0.05%–0.15% in drinking water ³³	Coccidiosis	
Sulfamethazine	100 mg/kg PO q24h ³³ 0.77 g/L drinking water ³³ 0.5%–1.0% in feed ³³	Coccidiosis	417
Sulfamethoxine	50 mg/kg PO on day 1, then 25 mg/kg PO q24h × 10–20 days ¹²	Coccidiosis; administer in evening (not morning) because of circadian variation in drug excretion and half-life ⁹⁵	418
Sulfaquinoxaline	0.02%–0.05% in drinking water ³³ 0.025%–0.1% in drinking water ⁸⁷ 0.04%–0.1% in drinking water ³⁷ 0.1%–0.15% in drinking water ³³ 1 mg/ml in drinking water ⁷¹ 0.025%–0.03% in feed × 4–6 wk ⁸⁷ 125–250 ppm in feed ³⁷	Coccidiosis/prevention Alternating 2 wk periods for 4–8 wk during weaning Coccidiosis Coccidiosis/treatment During weaning	
Thiabendazole	25–50 mg/kg PO ³³ 50–100 mg/kg PO q24h × 5 days ² 0.1% in feed × 3 mo ⁷⁶		
Thiabendazole/dexamethasone/neomycin (Tresaderm, MSD-AgVet)	3 drops in each ear q12h × 7–14 days ¹⁸	Ear mites; generally concurrent to ivermectin therapy	
Toltrazuril	25 ppm in drinking water (or 25 mg/kg PO) q24h × 2 days, repeat after 5 days ³⁵	Coccidiosis	418

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TABLE 54 Chemical restraint/anesthetic/analgesic agents used in rabbits.

Agent	Dosage	Comments
Acepromazine	— 0.25–1.0 mg/kg IM ^{37,42,51,113} 1–5 mg/kg SC, IM ³³	See ketamine, ketamine/xylazine for combinations Preanesthetic; sedative; tranquilizer Preanesthetic; lower end of dose range is preferred
Acetaminophen (Tylenol, McNeil)	— 200–500 mg/kg PO ³³ 1–2 mg/ml drinking water ⁴⁵	Acetaminophen combination follows Analgesia
Acetaminophen/codeine	1 ml elixir/100 ml drinking water ¹¹³	Analgesia; nonsteroidal antiinflammatory
Acetylsalicylic acid (aspirin)	10–100 mg/kg PO q8–12h ⁷¹ 100 mg/kg PO ^{32,50} q8–24h 100 mg/kg PO q48h ³⁷	Nonsteroidal antiinflammatory
Alfentanil (Alfenta, Taylor)	0.03–0.07 mg/kg IV ¹¹³	Intraoperative analgesia for 45 min duration
Atipamezole (Antisedan, Pfizer)	0.001 mg/kg SC, IV, IP ¹⁰⁵ Give same volume SC, IV, IP as medetomidine (5 × medetomidine dose in mg) ⁷¹	Medetomidine reversal
Atracurium	0.1 mg/kg IV ¹⁰³	Paralysis for intraophthalmic surgery; requires assisted ventilation
Atropine	0.1–0.5 mg/kg SC, IM ⁷¹ 0.1–3.0 mg/kg SC ³⁷ 0.8–1.0 mg/kg IM ⁴¹	Many rabbits possess serum atropinase, hence very high doses are often administered
Buprenorphine (Buprenex, Reckitt & Colman)	0.01–0.05 mg/kg SC, IP, IV q6–12h ^{32,37} 0.02–0.1 mg/kg SC, IV ⁵⁰ 0.5 mg/kg per rectum q12h ⁴⁵	Analgesia
Butorphanol (Torbugesic, Fort Dodge)	— 0.1–0.5 mg/kg SC, IM, IV q4h ^{32,42,50} 0.1–1.0 mg/kg SC, IM, IV q4–6h ⁷¹ 1–5 mg/kg SC q4–6h ⁶	See ketamine/xylazine for combination Analgesia Lower dose preferred ¹⁷
Carprofen (Rimadyl, Pfizer)	— 1.0–2.2 mg/kg PO q12h ⁷¹ 1.5 mg/kg PO q12h ^{35,42} 2.2 mg/kg PO q12h ⁸³ 2–4 mg/kg SC q24h ³⁵ 4 mg/kg SC, IM q24h ⁴²	Nonsteroidal antiinflammatory; chronic joint pain
Chlorpromazine	1–10 mg/kg IM, IV ³³	Preanesthetic; lower end of dose range is generally preferred
Codeine	—	See acetaminophen combination
Diazepam	— 1–3 mg/kg IM ³⁷ 1–5 mg/kg IM, IV ^{33,42} 1 mg/kg intracavernous ²⁶	See ketamine for combinations Preanesthetic; tranquilizer Preanesthetic; tranquilizer Seizures; alternative to IV route
Enflurane	To effect	Anesthesia; MAC = 2.9% ²⁵
Fentanyl	0.0074 mg/kg IV ⁶⁰	Analgesia

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Fentanyl patch	½ patch/medium-sized rabbit (3 kg) × 3 days ⁹¹	Postoperative analgesia; do not	
Fentanyl/droperidol (Innovar-Vet, Schering-Plough)	0.15–0.44 ml/kg IM ¹¹³	0.22 ml/kg optimal; may cause muscle necrosis at injection site	
Fentanyl/fluanisone (Hypnorm, Janssen)	0.2–0.3 ml/kg ³⁵	Premedication, analgesia, sedation	
Flunixin meglumine (Banamine, Schering)	— 0.3–2.0 mg/kg PO, IM, IV q12–24h ⁸³ 1.1 mg/kg SC, IM q12h ^{32,50} 1–2 mg/kg SC q12–24h ⁴¹	Analgesia; nonsteroidal antiinflammatory ⁶⁸ Use for no more than 3 days	
Glycopyrrolate (Robinul-V, Fort Dodge)	0.01–0.02 mg/kg SC ⁴⁵	Preanesthetic	420
Ibuprofen	— 2.0–7.5 mg/kg PO q4h ⁷¹ 7.5 mg/kg q6–8h PO ¹⁰⁰	Analgesia; nonsteroidal antiinflammatory; may have gastrointestinal side effects	421
Isoflurane	3%–5% induction, 1.5%–1.75% maintenance ³³ 3%–5% induction, 2%–3% maintenance ³⁷	Inhalant anesthetic of choice; MAC = 2.05%	
Ketamine	— 15–20 mg/kg IV ³³ 20–50 mg/kg IM ³³ 35–50 mg/kg IM ¹¹³	Ketamine combinations follow; should be administered in combination with other agents 60 min of sedation	
Ketamine (K)/acepromazine (A)	(K) 25–40 mg/kg + (A) 0.25–1.0 mg/kg IM, IV ⁴² (K) 40 mg/kg + (A) 0.5–1.0 mg/kg IM ⁵⁰	Anesthesia Anesthesia	
Ketamine (K)/diazepam (D)	(K) 10 mg/kg + (D) 0.5 mg/kg IV ⁷⁰ (D) 0.2–0.5 mg/kg IV, then (K) 10–15 mg/kg IV to effect ⁴¹ (K) 15 mg/kg + (D) 0.3 mg/kg IM ⁶⁷ (K) 20–30 mg/kg IM, then (D) 0.5 mg/kg IV at 5–10 min ⁴⁴ (K) 20–30 mg/kg + (D) 1–3 mg/kg IM ⁴⁴ (K) 20–40 mg/kg + (D) 1–5 mg/kg IM ⁴² (K) 30–40 mg/kg + (D) 2–5 mg/kg IM ¹⁸	Anesthesia; follow with isoflurane Sedation; use with isoflurane for anesthesia Anesthesia; follow with isoflurane Anesthesia; generally used with isoflurane; dentistry (with or without isoflurane) Anesthesia; use with isoflurane Surgical anesthesia; lower end of dose range for (D) is preferred ⁹⁰ ; less preferable than the forementioned (K)/(D) combinations	
Ketamine (K)/medetomidine (M)	(M) 0.1 mg/kg IV, then (K) 20 mg/kg IV at 15 min ⁸⁹ (M) 0.35 mg/kg IV, then (K) 5–20 mg/kg IV at 15 min ⁷¹	Anesthesia sufficient for cerebrospinal fluid spinal tap and cardiocentesis Note: high medetomidine dose	421
Ketamine (K)/midazolam (M)	(K) 25 mg/kg + (M) 2–5 mg/kg IM ⁷⁶	May be preferable to use (M) at <2 mg/kg ¹⁷	422
Ketamine (K)/xylazine (X)	— (K) 10 mg/kg + (X) 3 mg/kg IV ^{31,50} (K) 30–40 mg/kg + (X) 3–5 mg/kg IM ³³ (K) 35 mg/kg + (X) 5 mg/kg IM ⁵⁹	Anesthesia; may result in bradycardia; less preferable than (K)/(D)/isoflurane combinations; seldom indicated	

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Ketamine (K)/xylazine (X)/acepromazine (A)	(K) 35 mg/kg + (X) 5 mg/kg + (A) 0.75 mg/kg IM ⁵⁹	Anesthesia; may result in bradycardia; less preferable than (K)/(D)/isoflurane combinations; seldom indicated	
Ketamine (K)/xylazine (X)/butorphanol (B)	(K) 35 mg/kg + (X) 5 mg/kg + (B) 0.1 mg/kg IM ⁶³	Anesthesia; may result in bradycardia; less preferable than (K)/(D)/isoflurane combinations; seldom indicated	
Ketoprofen (Ketofen, Fort Dodge)	1 mg/kg IM q12–24h ⁸³ 3 mg/kg SC, IM q24h ⁴²	Musculoskeletal pain; nonsteroidal antiinflammatory	
Ketoprofen (2.5%) topical gel (Menarini, France)	Apply topically q6–12h ⁴	Musculoskeletal pain	
Lidocaine 1.5%	0.4 ml/kg epidural ⁹⁴	Epidural anesthesia	
Lidocaine 10%	Topical to glottis ⁴⁵	Facilitates intubation	
Medetomidine (Dormitor, Pfizer)	— 0.25 mg/kg IM ⁵⁵	Medetomidine combinations follow; see ketamine for combinations Sedation	
Medetomidine (M)/ketamine (K)	(M) 0.35 mg/kg IM + (K) 5 mg/kg IV ⁴³ (M) 0.35 mg/kg IM, then (K) 5–20 mg/kg IV at 15 min ⁷¹	Anesthesia; surgical depth approximately 19 min; note: high medetomidine dose ³⁰ Note: high medetomidine dose ³⁰	
Medetomidine (M)/propofol (P)	(M) 0.35 mg/kg IM + (P) 3 mg/kg IV ⁴³	Anesthesia; surgical depth approximately 11 min; note: high medetomidine dose ³⁰	422
Meloxicam (Metacam, Boehringer Ingelheim Vetmedica)	0.1–0.2 mg/kg PO q24h ³⁵ 0.2 mg/kg SC, IM q24h ⁴² 0.3 mg/kg PO q24h ⁴²	Nonsteroidal antiinflammatory; analgesia; antipyretic; used for osteoarthritis and postoperative pain; palatable PO form	423
Meperidine (Demerol, Winthrop-Breon)	5–10 mg/kg SC, IP q2–3h ³⁷ 10 mg/kg SC, IM q2–3h ^{32,42} 5–25 mg/kg SC, IM, IV ³³ 0.2 mg/ml drinking water ⁴⁵	Analgesia Analgesia	
Methoxyflurane	1%–3% induction, 0.3%–1.0% maintenance ³³ 2%–4% induction, 0.5%–2.0% maintenance ³⁷		
Midazolam (Versed, Roche)	— 1–2 mg/kg IM, IV, IP ^{37,51,71}	See ketamine for combination; more potent, shorter action than diazepam; rapidly absorbed IM; decreases uptake and increases elimination of procainamide ⁷⁹ Preanesthetic; tranquilizer	
Morphine	1.2–5.0 mg/kg SC, IM q2–4h ¹¹³ 2–5 mg/kg SC, IM q2–4h ^{32,42,50} 5–10 mg/kg SC, IM q4h ³³	Analgesia	
Nalbuphine (Nubain, Dupont)	1–2 mg/kg IM, IV q4–5h ⁴¹	Analgesia	
Nalorphine (Nalline Hydrochloride, Rhone Merieux)	1–5 mg/kg IV ³³	Narcotic reversal	
Naloxone	0.01–0.1 mg/kg IM, IV ³³	Narcotic reversal	
Oxymorphone	0.05–0.2 mg/kg SC, IM q8–12h ^{41,42} 0.2 mg/kg IM q2–4h ⁷⁴	Analgesia	
Pentazocine (Talwin-V, Upjohn)	5–10 mg/kg IM, IV q2–4h ¹¹³	Analgesia	423
Pentobarbital	20–45 mg/kg IV, IP ³⁷	Marginal analgesia; autonomic depression; not recommended	424

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Piroxicam (Feldene, Pfizer)	0.2 mg/kg PO q8h ⁴⁵	Analgesia; nonsteroidal antiinflammatory ⁶⁸
Promazine	1–2 mg/kg IM, IV ³³	Preanesthetic
Propofol	— 2–3 mg/kg IV ⁷⁶ 3–6 mg/kg IV ⁴² 7.5–15.0 mg/kg IV ²¹	See medetomidine for combinations Induction after premedication; maintain with approximately 1 mg/kg IV q15min ⁷⁶
Sevoflurane	To effect	Anesthesia; MAC = 3.7% ⁹⁶
Thiamylal	15–25 mg/kg IV to effect ¹¹³	
Thiopental	15–30 mg/kg IV to effect ¹¹³	
Tiletamine/zolazepam (Telazol, Fort Dodge)	3 mg/kg IM ³⁷	Sedation before gas anesthetic; caution: tiletamine causes severe renal tubular necrosis at 32 mg/kg and mild nephrosis at 7.5 mg/kg ²³ ; caution: not generally recommended for use in rabbits
Xylazine	— 1–5 mg/kg SC, IM ^{27,42}	See ketamine for combinations Preanesthetic; tranquilizer; lower end of dose preferred; seldom indicated
Yohimbine (Yobine, Lloyd)	0.2–1.0 mg/kg IM, IV ³³	Xylazine reversal

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TABLE 55 Ophthalmic drugs used in rabbits.

Agent	Dosage	Comments
Atropine (1%)	Topical to eyes q12h prn ⁵²	Mydriasis; systemic effects are possible
Atropine (1%)/phenylephrine (10%)	Topical to eyes ³⁷	Mydriasis for nonalbino eyes
Betaxolol (0.5%) (Betoptic, Alcon)	Topical to eyes q12h ⁵³	Glaucoma; effectively decreases intraocular pressure in rabbits
Ciprofloxacin (0.3%) (Ciloxan, Alcon)	Topical to eyes q8–12h ⁵²	Susceptible infections
Cyanoacrylate adhesive (Vetbond, 3M)	Topical to corneal ulcer ⁷⁸	Treatment of corneal ulcers, causes minimal inflammation
Cyclosporin A (0.2%) ointment (Optimmune, Schering-Plough)	Topical to eyes q12h ¹⁰⁷	Shown to increase tear production in rabbits
Dichlorophenamide (Daranide, Merck)	1–2 mg/kg PO q24h ⁵⁴	Glaucoma
Dorzolamide (Trusopt, Merck)	Topical to eyes q8–12 ⁵²	Glaucoma
Fusidic acid (Fucithalmic, Leo)	Topical to eyes q12–24h ³⁵	Bacterial conjunctivitis
Gentamicin (Tiacil, Virbac)	Topical to eyes q8h ³⁵	Bacterial conjunctivitis
Gestonorona (Primostat, Mexican Schering) (0.5 mg in 0.05 ml acidified water)	Intravitreal injection ¹⁹	Matrix metalloprotease inhibitor; single injection lasts for 4 wk; not available in the United States
Granulocyte macrophage colony stimulating factor (rhuGM-CSF)	Topical to eyes, 1 drop q6h ⁸	Superficial corneal wounds; use 4.8% solution (16 µg rhuGM-CSF in 33 µl saline buffered to pH 7.4)
Metipranolol (0.1%)/pilocarpine (2%)	Topical to eyes q8–12h ²⁴	Glaucoma
Neomycin-bacitracin-polymyxin B	Topical to eyes q6h ⁵²	Susceptible infections; corneal ulceration
Phenylephrine (10%)	— Topical to eyes	See atropine for combination Mydriasis ⁴⁸
Prednisolone acetate (1%) ophthalmic solution	Topical to eyes q6–12h ⁵²	Inflammation of eyes; rabbits are a corticosteroid-sensitive species ⁴⁹ ; if used, use with extreme caution
Timolol (0.5%) (Timoptic, Merck)	Topical to eyes q12h ⁵³	Glaucoma
Tissue plasminogen activator	25 µg intraocular injection ¹⁰³	Intraocular fibrin
Tropicamide (1%)	Topical to eyes ³⁷	Mydriasis

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TABLE 56 Miscellaneous agents used in rabbits.

Agent	Dosage	Comments
Activated charcoal (1 g/5 ml water)	1 g/kg PO q4–6h	Shown to reduce intestinal absorption of isoniazid and may be helpful in other cases of oral intoxication ⁷⁴
Aluminum hydroxide	30–60 mg/kg PO q8–12h ¹³	Phosphorus binder; hyperphosphatemia caused by renal failure
Barium	10–14 ml/kg PO ⁸⁷	Gastrointestinal contrast studies
Bromelain enzyme	— 1–2 tablets/animal PO q24h × 3–5 days ⁸⁷ 1–2 tablets/animal PO q24h × 2–3 days ⁸⁷	Efficacy has not been determined; generally not included in most trichobezoar treatment strategies Trichobezoars, gastric stasis; in fresh pineapple juice Preventative for heavy hair shedders; use every few months
Bupranolol with dlmonene	Apply topically q24h ⁷⁵	Experimental formulation, dlmonene may be useful to increase transdermal uptake of other topical drugs; not available in the United States
Calcium EDTA (edetate calcium disodium) (Calcium Disodium Versenate, 3M)	13–27 mg/kg SC, IV ³⁵ 27 mg/kg SC q6–12h prn ^{71,105}	Chelation therapy Lead toxicosis; diluted to <10 mg/ml with 0.45% NaCl/2.5% dextrose
Cellulose powder (Unifiber, Niche)	½–1 tsp/feeding ⁸⁸	Nonsoluble fiber source for rabbits on liquid enteral diets; will pass through small-diameter feeding tubes
Chlorphenamine maleate	0.2–0.4 mg/kg PO q12h ³⁵	Antihistamine
Cholestyramine (Questran Light, Squibb)	2 g/animal PO q24h × 18–21 days ³⁷	Ion exchange resin for toxin absorption after inappropriate antibiotic administration; use for treating enterotoxemia; gavage with 20 ml water; may result in constipation
Chondroitin sulfate (Cosequin, Nutramax)	Used empirically at feline dose ¹⁰⁸	Arthritis; a nutraceutical
Cimetidine (Tagamet, SmithKline Beecham)	5–10 mg/kg q6–12h ²	Gastric and duodenal ulcers
Cisapride (Propulsid, Janssen)	0.5 mg/kg PO q8–12h ⁴⁴	Enhances gastrointestinal motility; used for gastrointestinal stasis; not commercially available in the United States
Cyclizine	8 mg/rabbit PO q12h ¹⁰⁸	Torticollis (used to treat labyrinthine disorders in humans)
Dexamethasone	— 0.2–0.6 mg/kg SC, IM, IV ³³ 0.5–2.0 mg/kg PO, SC, then decreasing dose q12h × 3–14 days ³⁷ 2 mg/kg IM, IV ¹⁸	Corticosteroids are seldom indicated in rabbits; rabbits are a corticosteroid-sensitive species; if used, use with extreme caution and concurrent to a gastric protectant Antiinflammatory Shock; effectiveness is controversial
Digoxin	0.005–0.01 mg/kg PO q24–48h ⁷¹	Congestive heart failure; atrial fibrillation
Diphenhydramine (Benadryl, Parke-Davis)	2 mg/kg PO, SC q8–12h ⁷¹	Torticollis (used to treat labyrinthine disorders in humans)
Doxapram	2–5 mg/kg SC, IV q15min ⁴⁵	Respiratory stimulant

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Epinephrine	0.2 mg/kg IV ⁹⁰ 0.2–0.4 mg/kg IT ⁹⁰	Cardiac arrest Cardiac arrest	
Epoetin alpha, recombinant (Epogen, Amgen)	50–150 IU/kg SC q2–3d ¹³	Biosynthetic form of erythropoietin; treatment of anemia; use until PCV is normal, then q7d for at least 4 wk	
Fecal transfaunation	Mix fresh cecotrophs with warm saline, strain through gauze, and administer by gavage ⁴⁵	Dysbiosis; placement of E-collar on donor facilitates collection of sample	
Ferrous sulfate	4–6 mg/kg PO q24h ¹³	Iron deficiency anemia	
Furosemide	— 0.3–2.0 mg/kg SC, IM, IV ³⁵ 1–4 mg/kg IM q4–6h ³⁸ 2–5 mg/kg PO, SC, IM, IV q12h ⁷¹ 5–10 mg/kg q12h ²	Diuretic	
Fusafungine (Locabital, Servier)	Spray in nares q12h × 10 days ⁸¹	Bacterial rhinosinusitis; not available in the United States	428
Hairball laxative, feline	— 1–2 ml/animal PO q24h × 3–5 days ⁸⁷	Efficacy in treating trichobezoars has not been determined; generally not included in most trichobezoar treatment strategies Trichobezoars, gastric stasis	429
Hetastarch (Hespan, DuPont)	20 ml/kg IV ⁷³	Volume expansion in hypoproteinemic patients; may be of benefit in endotoxemia	
Human chorionic gonadotropin (hCG)	20–25 IU/animal IV ³⁷	Ovulation	
Hydroxyzine (Atarax, Roering)	2 mg/kg PO q8–12h ⁷¹	Antihistamine; antipruritic	
Iron dextran	4–6 mg/kg IM once ⁷¹	Iron deficiency anemia (treatment or prevention)	
Lactated Ringer's solution	60–90 ml/kg ⁵	Treatment for shock	
Lactobacilli	— Administer PO during antibiotic treatment period, then 5–7 days beyond cessation ²²	May aid in treatment of enteritis ⁸⁷ ; efficacy not determined Give 2 hr before or 2 hr after antibiotic treatment	
Lidocaine	1–2 mg/kg IV (bolus) ⁹¹ 2–4 mg/kg IT ⁹¹	Cardiac arrhythmia Cardiac arrhythmia	
Loperamide (Imodium A-D, McNeil)	0.1 mg/kg PO q8h × 3 days, then q24h × 2 days ³⁷	Enteropathies (nonspecific diarrhea); give in 1 ml water	
Meclizine (Antivert, Roering)	2–12 mg/kg PO q24h ³⁷ 12.5–25 mg/kg PO q8–12h ⁵¹	Reduces disorientation and rolling with torticollis (prevents motion sickness in small animals)	
Metoclopramide (Reglan, Robins)	0.2–0.5 mg/kg PO, SC q6–8h ⁴⁴ 0.2–1.0 mg/kg PO, SC q6–8h ³⁷ 0.5 mg/kg PO, SC q4–12h ⁵¹	Stimulates gastrointestinal motility; gastric stasis, trichobezoars	
Oxytocin	0.1–3.0 U/kg SC, IM ^{35,37}	Use in delayed, but unobstructed, parturition; agalactia	
Nandrolone (Deca-Durabolin, Organon)	2 mg/kg SC, IM ³⁵	Anabolic steroid; appetite stimulant; adjunct to treatment for anemia, especially in chronic renal failure	429

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Papain enzyme	—	Efficacy has not been determined; not generally recommended as part of a trichobezoar treatment or prevention strategy	430
	1–2 tablets/animal PO q24h × 3–5 days ⁸⁷ 1–2 tablets/animal PO q24h × 2–3 days ⁸⁷	Trichobezoars, gastric stasis Preventive for heavy hair shedders; use every few months	
Pineapple juice (fresh)	—	See bromelain enzyme for comments	
	10 ml/medium-size animal PO q24h × 3–5 days ^{44,87} 10 ml/medium-size animal PO q24h × 2–3 days ⁸⁷	Trichobezoars, gastric stasis; must use fresh juice, not canned; repeat in 3–5 days if no resolution ⁸⁷ Preventative for heavy hair shedders; use every few months	
Polysulfated glycosaminoglycan (Adequan, Luitpold)	2.2 mg/kg SC, IM q3d × 21–28 days, then q14d ⁵¹	Noninfectious, traumatic, or degenerative joint disease	
Potassium citrate	33 mg/kg q8h ¹¹³	Urinary calculi; may decrease calcium-based stone formation	
Prednisolone	—	See dexamethasone for comments	
	0.25–0.5 mg/kg PO q12h × 3 days, then q24h × 3 days, then q48h ⁸⁷ 0.5–2.0 mg/kg PO q12h ⁷¹	Treatment of nonresponsive torticollis, when negative for pasteurellosis; give antibiotics concurrently	
Prednisone	—	See dexamethasone for comments	
	0.5–2.0 mg/kg PO ^{2,18}	Antiinflammatory	
Prochlorperazine (Compazine, SmithKline Beecham)	0.2–0.5 mg/kg PO q8h ³⁵	Torticollis; doses as high as 30 mg/kg q8h are used to treat labyrinthine (antivertigo) disorders in humans	
Ranitidine (Zantac, Glaxo Wellcome)	2 mg/kg IV q24h ³⁵ 2–5 mg/kg PO q12h ³⁵	Gastric ulceration (often in inappetent rabbits)	
Simethicone (Mylanta, Johnson & Johnson)	65–130 mg/animal q1h × 2–3 treatments ⁵⁸	May reduce abdominal discomfort associated with excess gas	
Sodium bicarbonate	2 mEq/kg IV, IP ³⁸	Ketoacidosis (pregnancy toxemia); dosage is approximate	430
Stanozolol (Winstrol-V, Upjohn)	1–2 mg PO once ³⁷	Stimulates appetite after surgery or illness	431
Sucralfate (Carafate, Hoechst Marion Roussel)	25 mg/kg PO q8–12h ³⁷	Gastrointestinal ulcers; may interfere with other orally administered drugs	
Sulfasalazine (Azulfidine, Pharmacia)	1/8–1/4 crushed 500 mg tablet/animal q8–24h ⁵⁸	May reduce inflammation of intestinal mucosa	
Verapamil (Isoptin, Knoll)	0.2 mg/kg SC q8h × 9 treatments ^{35,37,51} 2.5–25 µg/kg/hr IP ¹⁰²	Slow-channel calcium blocking agent; post-operatively to decrease adhesion formation	
Viokase-V (Fort Dodge)	—	See pineapple juice	
	2–3 ml PO q12h ²	Enzymes; trichobezoars, gastric stasis; 1 tsp added to carrier; no direct effect on hair but may be efficacious in digesting the matrix of the trichobezoar	
Vitamin C (ascorbic acid)	100 mg/kg PO q12h ¹²	Nutritional supplement	
Vitamin K	1–10 mg/kg IM prn ¹⁰⁰	Select bleeding disorders and toxicities	431

APPENDIX 70 Hematologic and serum biochemical values of rabbits.^{44,50}

432

Measurement	Normal Values
HEMATOLOGY	
PCV (%)	30–50
Hb (g/dl)	8.0–17.5
RBC ($10^6/\mu\text{l}$)	4–8
MCV (fl)	58.0–66.5
MCH (pg)	17.5–23.5
MCHC (g/dl)	29–37
Platelets ($10^3/\mu\text{l}$)	290–650
WBC ($10^3/\mu\text{l}$)	5–12
Neutrophils (%)	35–55
Lymphocytes (%)	25–50
Monocytes (%)	2–10
Eosinophils (%)	0–5
Basophils (%)	2–7
CHEMISTRIES	
AP (IU/L)	4–16
ALT (IU/L)	14–80
AST (IU/L)	14–113
Bicarbonate (mEq/L)	16.2–31.8
Bilirubin, total (mg/dl)	0–0.75
Calcium (mg/dl)	8–14
Chloride (mEq/L)	92–112
Cholesterol (mg/dl)	35–60
Creatinine (mg/dl)	0.8–2.5
Glucose (mg/dl)	75–150
LDH (IU/L)	34–129
Lipids, total (mg/dl)	280–350
Phosphorus (mg/dl)	2.3–6.9
Potassium (mEq/L)	3.7–6.8
Protein, total (g/dl)	5.4–7.5
Albumin (g/dl)	2.5–4.5
Globulin (g/dl)	1.9–3.5
Sodium (mEq/L)	138–155
Triglycerides (mg/dl)	124–156
Urea nitrogen (mg/dl)	15–30

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APPENDIX 71 Biologic and physiologic data of rabbits.³⁶

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Parameter	Normal Values
Adult body weight, male (buck)	2–5 kg
Adult body weight, female (doe)	2–6 kg
Birth weight	30–80 g
Respiratory rate	30–60 breaths/min
Tidal volume	4–6 ml/kg
Heart rate	130–325 beats/min
Rectal temperature	38.5° C–40.0° C (101.3° F–104.0° F)
Life span	5–6 yr (up to 15 yr)
Food consumption	5 g/100 g/day
Water consumption	5–10 ml/100 g/day
Gastrointestinal transit time	4–5 hr
Breeding onset, male	6–10 mo
Breeding onset, female	4–9 mo
Breeding life of female	4 mo to 3.75 yr
Reproductive cycle	Induced ovulation
Gestation period	29–35 days
Litter size	4–10
Weaning age	4–6 wk

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APPENDIX 72 Urinalysis values in rabbits.⁸⁷

434

Measurement	Normal Values
Urine volume	
Large breeds	20–350 ml/kg/day
Average breeds	130 ml/kg/day
Specific gravity	1.003–1.036
Average pH	8.2
Crystals	Ammonium magnesium phosphate, calcium carbonate monohydrate, anhydrous calcium carbonate
Casts, epithelial cells, or bacteria	Absent to rare
Leukocytes or erythrocytes	Occasional
Albumin	Occasional in young rabbits

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APPENDIX 73 Cerebrospinal fluid values in rabbits.¹¹¹

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Measurement	Normal Values
Glucose	75 mg/dl
Urea nitrogen	20 mg/dl
Creatinine	17 mg/dl
Cholesterol	33 mg/dl
Total protein	59 mg/dl
Alkaline phosphatase	5.0 U/dl
Carbon dioxide	41.2–48.5 ml%
Sodium	149 mEq/L
Potassium	3 mEq/L
Chloride	127 mEq/L
Calcium	5.4 mEq/L
Magnesium	2.2 mEq/L
Phosphate	2.3 mEq/L
Lactic acid	1.4–4.0 mg/dl
Nonprotein N	5.6–16.8 mg/dl

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APPENDIX 74 Electrocardiographic values in rabbits.⁴⁶

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ECG Parameter	Normal Values
Heart rate	198–330 beats/min ^a
Measurements (lead II)	
P wave	
Duration (width)	0.01–0.05 sec
Amplitude (height)	0.04–0.12 mv
P-R interval	
Duration	0.04–0.08 sec
QRS complex	
Duration	0.02–0.06 sec
R-wave amplitude	0.03–0.039 mv
Q-T interval	
Duration	0.08–0.16 sec
T wave	
Amplitude	0.05–0.17 mv
Electrical axis (frontal plane)	–43 to +80 degrees

a Lower values may be expected in acclimated rabbits.

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APPENDIX 75 Determining the sex of mature rabbits.⁹⁷

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Male	Female
• Protrude penis by manipulating skin of prepuce.	• There is a common orifice for both the vagina and urethra (like dogs and cats).
• Palpate for testicles.	• No structure like a “penis” can be protruded from the urogenital orifice.
• Anogenital distance is longer.	• Anogenital distance is shorter.

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APPENDIX 76 Drugs reported to be toxic in rabbits.^a

Drug	Comments
Amoxicillin ⁴⁴	Enteritis; enterotoxemia
Amoxicillin/clavulanic acid ⁴⁴	Enteritis; enterotoxemia
Ampicillin ^{16,35}	Enteritis; enterotoxemia, high risk especially if given orally
Cephalosporins ^{23,35}	Enteritis; enterotoxemia if given orally
Clindamycin ^{16,35}	Enteritis; enterotoxemia, high risk
Erythromycin ¹⁶	Enteritis; enterotoxemia
Lincomycin ^{16,35}	Enteritis; enterotoxemia, high risk
Penicillin ^{16,35}	Enteritis; enterotoxemia if given orally
Procaine ³⁶	May be fatal at doses of 0.4 mg/kg
Tiletamine ²³	Nephrotoxic

- a There have also been some reports of antibiotic-related colitis in rabbits given penicillin/streptomycin, trimethoprim/sulfamethoxazole, tetracycline, and gentamicin. In general, parenteral antibiotic therapies are preferred over oral.

APPENDIX 77 Medical treatment for gastric stasis/ileus and trichobezoars in rabbits. [a,18,37,44,58,66,70,87,106](#)

Treatment	Comments
Analgesics (see Table 54)	• Use for abdominal discomfort, thereby stimulating appetite
Antibiotics (see Table 52)	• Use only when indicated; enrofloxacin or trimethoprim/sulfa are generally the drugs of choice; use parenterally until stools are passed; metronidazole may be indicated for anaerobe overgrowth
Exercise	• Increasing activity may aid in passage of trichobezoars
Fluid therapy	• Rehydration (PO, SC, IV) is essential
Oral (gastric) hydration	• Maintenance fluids is $\times 100$ –120 ml/kg/day • Important to rehydrate any material in stomach • Can use balanced electrolyte solutions
Grooming	• Brushing the hair may prevent an exacerbation of the problem • Routinely brushing long-haired or heavy-shedding individuals for prevention
Nutritional support	• Important in the anorectic rabbit; helps prevent hepatic lipidosis • Force-feed $\times 10$ –15 ml/kg q8–12h Critical Care for Herbivores (Oxbow Pet Products) or blenderized alfalfa pellets in electrolyte solution (e.g., Pedialyte, Ross), lactated Ringer's solution, or water, and vegetable baby foods (without added sugar) • Offer fresh greens (parsley, romaine lettuce, carrot tops, kale, etc.) and timothy or grass hay ad libitum • Vitamin supplements (especially vitamin B) prn
Motility modifiers	• Promotes gastric emptying • Metoclopramide (0.2–0.5 mg/kg PO, SC q6–8h) • Cisapride (0.5 mg/kg PO q8–12h)
Other treatments	• Cholestyramine: treating/preventing enterotoxemia (see Table 56) • Simethicone: may reduce abdominal discomfort associated with excess gas (see Table 56) • Sulfasalazine: may reduce inflammation of intestinal mucosa (see Table 56)
Laxative, feline	• Because their effectiveness is equivocal, petroleum-based laxatives are probably not indicated
Enzyme supplements	• Use of proteolytic enzymes such as bromelain (present in fresh pineapple juice) have also been used empirically in cases of trichobezoars; however, their contribution to resolving the problem is equivocal, and they are generally not recommended in most treatment strategies

- a Concurrent to treatment, it is important to correct the cause (e.g., boredom, stress, excessive shedding, inadequate dietary roughage, nutritional deficiency or imbalance, obesity). Surgical intervention is no longer considered the preferred treatment.

8.1 APPENDIX 78 Literature cited-rabbits.

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 Ferrets

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Carol Gamble, DVM, Diplomate ABVP (Avian)

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TABLE 57 Antimicrobial and antifungal agents used in ferrets.

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Agent	Dosage	Comments
Amikacin	8–16 mg/kg SC, IM, IV divided q8–24h ^{54,88} 10–15 mg/kg SC, IM q12h ⁸	Potentially ototoxic and nephrotoxic
Amoxicillin	— 10–20 mg/kg PO q12h ⁸ 20 mg/kg PO, SC q12h ³⁴ 30 mg/kg PO q8h ²⁷ × 21 days	Can use with metronidazole and bismuth subsalicylate for <i>Helicobacter</i>
Amoxicillin/clavulanic acid (Clavamox, Pfizer)	12.5 mg/kg PO q12h ⁹ 13–25 mg/kg PO q8–12h ³⁴	
Amphotericin B	0.4–0.8 mg/kg IV q7d ⁷	Blastomycosis; monitor for azotemia; total dose 7–25 mg
Ampicillin	5–30 mg/kg SC, IM, IV q8–12h ^{9,54}	
Cefadroxil (Cefadrops, Fort Dodge)	15–20 mg/kg PO q12h ⁹	
Cephalexin (Keflex, Dista)	15–25 mg/kg PO q12h ⁹ 15–30 mg/kg PO q8h ³⁴	
Cephaloridine	10–15 mg/kg SC, IM q24h × 5–7 days ⁸ 10–25 mg/kg SC, IM q24h × 5–7 days ⁷⁷	Dermatitis
Chloramphenicol	25–50 mg/kg PO q12h ⁸ 30–50 mg/kg SC, IM, IV q12h ^{8,16} 50 mg/kg PO, SC, IM, IV q12h ^{33,34}	14-day minimum for proliferative bowel disease ^{33,34}
Ciprofloxacin (Cipro, Bayer)	— 5–15 mg/kg PO q12h ⁹ 10–30 mg/kg PO q24h ⁹	Mix 500 mg tablet in 10 ml water (50 mg/ml)
Clarithromycin (Biaxin, Abbott)	12.5 mg/kg PO q8–12h × 14 days ^{41,45} 50 mg/kg PO q24h or divided q12h × 14 days ⁵²	<i>Helicobacter</i> ; use with ranitidine bismuth citrate <i>Helicobacter</i> ; use with omeprazole (or ranitidine) and metronidazole
Clindamycin	5.5–10.0 mg/kg PO q12h ⁹	Anaerobic infections; bone and dental disease
Cloxacillin	10 mg/kg PO, IM, IV q6h ⁷	

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Enrofloxacin (Baytril, Bayer)	5–10 mg/kg PO, SC, IM q12h ⁹	IM for short term (generally 1 injection); injectable form can be given PO in palatable liquid ⁹ ; liquid for PO can also be compounded
	8.5 mg/kg PO q24h or divided q12h ⁴¹	
	10–20 mg/kg PO, SC, IM q12h ⁸⁸	
	10–20 mg/kg PO, SC, IM q24h ⁹	
	10–30 mg/kg PO, SC, IM q24h ⁷¹	
Erythromycin	10 mg/kg PO q6h ⁷ 220 g/ton feed ²⁵	Controlling <i>Campylobacter</i> diarrhea in large groups
Gentamicin	2 mg/kg PO q12h × 10–14 days ¹⁹	Parenteral form can be given PO; proliferative colitis that is non-responsive to chloramphenicol ^{8,19} If given IV, dilute with saline and administer over 20 min
	2–4 mg/kg SC, IM, IV q12h ⁹	
	5 mg/kg SC, IM q24h ¹⁶	
Griseofulvin	25 mg/kg PO q12 ⁵⁴ –24h ³⁴	Refractory dermatomycosis; use with lime sulfur dips q7d ³⁴
Ketoconazole	10–30 mg/kg PO q8h ⁷	
	10–30 mg/kg PO q12–24h ⁸⁸	
	10–50 mg/kg PO q12–24h ⁴²	
Lime sulfur	Dip q7d ³⁴	Dermatomycosis; see Griseofulvin
Lincomycin	11 mg/kg PO q8h ⁷	
Metronidazole	—	Anaerobic infections; can use with amoxicillin and bismuth subsalicylate for <i>Helicobacter</i>
	15–20 mg/kg PO q12h ⁸	
	20 mg/kg PO q12h ^{33,34}	
	50 mg/kg PO q24h ¹⁶	<i>Helicobacter</i> ; use with clarithromycin and omeprazole
	75 mg/kg PO q24h ⁵³ × 14 days	
Neomycin	10–20 mg/kg PO q6h ^{7,16}	448
Netilmicin (Netromycin, Schering)	6–8 mg/kg SC, IM, IV q24h ⁷⁹	Severe staphylococcal infections
Oxytetracycline	20 mg/kg PO q8h ^{7,8,16}	449
Penicillin G (sodium or potassium)	20,000 IU/kg IM q12h ⁴²	
	40,000–44,000 IU/kg SC, ⁵⁴ IM q24h ^{7–9}	
Sulfadimethoxine	25 mg/kg PO, SC, IM q24h ⁹	
	30–50 mg/kg PO q12–24h ¹⁶	
Sulfamethazine	1 mg/ml drinking water ¹⁶	
	1–5 mg/ml drinking water ⁵²	
Sulfasoxazole	50 mg/kg PO q8h ⁹	

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Tetracycline	20 mg/kg PO q8h ¹⁶	
	25 mg/kg PO q12h ⁸	
Trimethoprim/sulfa	5 mg/kg PO q24h ²⁸	Pyelonephritis
	15–30 mg/kg PO, SC q12h ³⁴	
Tylosin (Tylan, Elanco)	5–10 mg/kg IM, IV q12h ¹⁶	
	10 mg/kg PO, SC q8–12h ^{9,16,54}	

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TABLE 58 Antiparasitic agents used in ferrets.

Agent	Dosage	Comments
Amitraz (Mitaban, Upjohn)	Topical to affected area q7–14d × 3–6 treatments ^{54,79}	Demodectosis; use full concentration
Amprolium	19 mg/kg PO q24h ⁹	Coccidiosis
Carbaryl powder (5%)	Topical q7d × 3–6 treatments ⁹	Ectoparasites
Diethylcarbamazine	5–11 mg/kg PO q24h ^{7,34}	Heartworm preventative; rarely used; ivermectin preferred
Fenbendazole	20 mg/kg PO q24h × 5 days ⁵² 50 mg/kg PO q24h × 30 days ¹	<i>Mesocestoides</i> infection
Fipronil (Frontline, Merial)	1 pump of spray or 1/5–1/2 of cat pipette topical q60d ⁵¹	Flea adulticide
	0.2–0.4 ml topically q30d ⁸⁸	
Imidacloprid (Advantage, Bayer)	1 cat dose divided onto 2–3 spots along dorsum q30d ⁵¹ 0.1 ml topically q30d ⁸⁸	Flea adulticide Use small cat/kitten vial
	0.4 ml topically q30d ⁴²	
Ivermectin	0.05 mg/kg PO q30d ^{34,83} 0.05 mg/kg PO, SC ^{34,83} 0.055 mg/ferret PO q30d ³⁴ 0.2–0.5 mg/kg SC, repeat q14d × 3 treatments ³⁴ 0.4 mg/kg PO, SC, repeat in 14–28 days ^{34,68} 0.5–1.0 mg/kg in ears, repeat in 14 days ^{9,34}	Heartworm preventative; administer 1 mo before and continue to 2 mo after possible mosquito exposure Heartworm microfilaricide; 3–4 wk postadulticide treatment Heartworm preventative (Heartgard, Merial); use small cat dose Sarcoptic mange Ear mites; half dose in each ear; treat cats and dogs in house concurrently
Lime sulfur	Dip 1:40 dilution q7d × 6 wk ⁸⁸	
Lufenuron (Program, Novartis)	30–45 mg/kg PO q30d ⁵¹	Flea larvicide
Melarsomine dihydrochloride (Immiticide, Rhône Merieux)	2.5 mg/kg IM once, repeat in 30 days with 2 treatments 24 hr apart ⁹	Heartworm adulticide; possible therapeutic option in place of thiacetarsamide; use prednisone (1 mg/kg q24h × 4 mo) after treatment
Metronidazole	15–20 mg/kg PO q12h × 14 days ⁸	Gastrointestinal protozoa
Milbemycin oxime (Interceptor, Novartis)	1.15–2.33 mg/kg PO q30d ⁷⁹	Heartworm preventative
Piperazine	50–100 mg/kg PO q14d ⁹	Intestinal nematodes
Praziquantel (Droncit, Bayer)	5–10 mg/kg PO, SC, repeat in 10 ⁵⁴ –14d ⁸	Cestodes
Pyrantel pamoate	4.4 mg/kg PO, repeat in 14 days ⁹	
Pyrethrins	Topical q7d prn ⁵¹	Fleas; use products safe for puppies and kittens
Selamectin (Revolution, Pfizer)	6–10 mg/kg topically ^{48,53}	Ectoparasites (fleas, lice, most mites except <i>Demodex</i>); doses of up to 10–12 mg/kg have also been recommended

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Sulfadimethoxine	20–50 mg/kg PO q24h ⁸ 50 mg/kg PO, then 25 mg/kg q24h × 9 days ⁸	Coccidia
Thiabendazole/dexamethasone/neomycin (Tresaderm, Merial)	2 drops in each ear daily × 7 days, off 7 days, on 7 days ⁶⁰	Ear mites
Thiacetarsemide (Caparsolate, Rhone Merieux)	2.2 mg/kg IV q12h × 2 days ^{24,34,82}	Heartworm adulticide; follow 3–4 wk later with ivermectin ³⁴ ; use heparin (100 U/animal [0.45–1.35 kg] SC q24h × 21 days) concurrently to reduce risk of thromboemboli formation; after 3 wk, change heparin to aspirin (22 mg/kg PO q24h × 3 mo ⁸²); not commonly used

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TABLE 59 Chemical restraint/anesthetic agents used in ferrets.

Agent	Dosage	Comments
Acepromazine	— 0.10–0.25 mg/kg SC, IM ^{8,22,75} 0.2–0.5 mg/kg SC, IM ^{22,75}	See ketamine for combination Preanesthetic; light sedation Tranquilization
Alphaxalone/alphadalone (Saffan, Glaxovet)	6–8 mg/kg IM ⁴⁴ 8–12 mg/kg IV ¹⁴	Anesthesia; used mostly in laboratory situations; not available in the United States
Atipamezole (Antisedan, Pfizer)	0.4 mg/kg IM ¹⁸ 1 mg/kg SC, IV, IP ²¹	Medetomidine reversal Medetomidine reversal
Atropine	0.04–0.05 mg/kg SC, IM, IV ^{22,31,34,75}	Preanesthetic; bradycardia; hypersalivation
Diazepam	— 0.5 mg/kg PO, IM, IV q6–8h ⁶⁴ 0.5–1.0 mg/kg/hr constant-rate infusion ⁴ ≤1 mg/kg IM ⁸ 1 mg/animal IV ³⁴ 1.0–1.5 mg/hr continuous IV ³⁴ 1–2 mg/kg IM ^{8,22}	See ketamine for combinations Smooth muscle relaxation in urethral obstruction cases Seizure control Stimulates appetite Seizure control; 1–2 boluses Status epilepticus control Tranquilization; seizure control ³
Enflurane	2% maintenance ¹⁸	Anesthesia
Fentanyl citrate/flunixin (Hypnorm, Janssen)	0.3 mg/kg IM ¹⁸	Anesthesia; not available in the United States
Fentanyl/droperidol (Innovar-Vet, Schering Plough)	0.15 ml/kg IM ²⁰	Minor surgical procedures; deep sedation
Glycopyrrolate	0.01 mg/kg IM ³¹	Preanesthetic; bradycardia; hypersalivation
Halothane	3.0%–3.5% induction; 0.5%–2.5% maintenance ²²	Anesthesia
Isoflurane	5% induction; 2%–3% maintenance ⁸	Inhalant anesthetic agent of choice
Ketamine	— 10–20 mg/kg IM ²² ≤20 mg/kg IM ³¹ 30–60 mg/kg IM ²²	Ketamine combinations follow Tranquilization Induction; higher doses may cause apnea Anesthesia
Ketamine (K)/acepromazine (A)	(K) 20–35 mg/kg + (A) 0.20–0.35 mg/kg SC, IM ^{34,75}	Anesthesia
Ketamine (K)/diazepam (D)	(K) 10–20 mg/kg (D) 1–2 mg/kg IM ³⁴ (K) 25–35 mg/kg (D) 2–3 mg/kg IM ^{8,50} 0.1 ml/kg IV ¹⁸	Anesthesia; poor analgesia ⁵⁰ Induction; will allow intubation with premedication; use equal volumes of (K) at 100 mg/ml and (D) at 5 mg/ml
Ketamine (K)/medetomidine (M)	(K) 5 mg/kg (M) 0.08 mg/kg IM ¹⁸ (K) 8 mg/kg (M) 0.1 mg/kg ²¹ IM	Induction Anesthesia; analgesia; may result in hypotension and respiratory depression
Ketamine (K)/medetomidine (M)/butorphanol (B)	(K) 5 mg/kg + (M) 0.08 mg/kg + (B) 0.1 mg/kg IM ¹⁸	Induction

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Ketamine (K)/midazolam (M)	0.1 ml/kg IV ¹⁸ (K) 5–10 mg/kg +(M) 0.25–0.5 mg/kg IV ⁵⁴	Induction; use equal volumes of (K) at 100 mg/ml and (M) at 5 mg/ml	
Ketamine (K)/xylazine (X)	(K) 10–25 mg/kg +(X) 1–2 mg/kg IM ^{34,50}	Anesthesia; avoid in sick animals ³⁴ ; may result in cardiac arrhythmias ⁵⁰	453
Medetomidine (Dormitor, Pfizer)	— 0.08–0.2 mg/kg SC, IM ¹⁴ 0.1 mg/kg SC, IM ²¹	Medetomidine combination follows; see ketamine for combinations May cause hypertension and bradycardia; use with caution in sick animals Light sedation	
Medetomidine (M)/butorphanol (B)	(M) 0.08 mg/kg +(B) 0.1 mg/kg IM ⁴⁴	Anesthesia; monitor blood pressure and ventilation	
Methoxyflurane	1%–3% induction ²²	Anesthesia	
Midazolam (Versed, Roche)	— 0.3–1.0 mg/kg SC, IM ¹¹	See ketamine for combination Mild sedation; premedication	454
Morphine	0.1 mg/kg ⁷⁸	Epidural anesthesia; see Table 60 for analgesia	
Naloxone (Narcan, Dupont)	0.01–0.03 mg/kg IM, IV ¹⁴ 0.04 mg/kg SC, IM, IV ¹⁰	Reversal of opioids	
Pentobarbital	1–2 mg/kg PO q12h ⁹ 30–50 mg/kg IP ⁹⁰	Seizure control; use oral elixir Anesthesia; minimal analgesia; respiratory depression; prolonged recovery; other agents preferred	
Propofol	2–5 mg/kg IV ^{17,18} 5–8 mg/kg IV ¹⁴	Induction	
Sevoflurane	To effect ⁵⁴	Anesthesia	
Thiopental (2%)	8–12 mg/kg IV ^{17,18}	Induction	
Tiletamine/zolazepam (Telazol, Fort Dodge)	12–22 mg/kg IM ⁶²	Minor surgical procedures at 22 mg/kg; recovery may be prolonged at higher doses; rarely indicated	
Xylazine	— 1 mg/kg SC, IM ²²	See ketamine for combination Tranquilization; may cause hypotension, bradycardia, and arrhythmias; use with care in sick animals	
Yohimbine (Yobine, Lloyd)	0.2 mg/kg IV ¹⁴ 0.5 mg/kg IM ^{14,84}	Xylazine reversal	454

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TABLE 60 Analgesic agents used in ferrets.

Agent	Dosage	Comments
Acetylsalicylic acid (aspirin)	0.5–22.0 mg/kg PO q8–24h ³⁴ 10–20 mg/kg PO q24h ⁸⁸	Analgesia; antiinflammatory; antipyretic
Buprenorphine (Buprenex, Reckitt & Colman)	0.01–0.03 mg/kg SC, IM, IV q8–12h ^{31,47} 0.01–0.05 mg/kg SC, IM, ⁸⁸ IV ¹⁰ q8–12h	Analgesia
Butorphanol (Torbugesic, Fort Dodge)	— 0.05–0.5 mg/kg SC, IM q8–12h ^{9,47} 0.1–0.5 mg/kg SC, IM, IV q4–6h ^{10,14}	See ketamine, medetomidine in Table 59 for anesthetic combinations Analgesia
Carprofen (Rimadyl, Pfizer)	1 mg/kg PO q12–24h ⁹	Nonsteroidal antiinflammatory; use with caution in animals with gastritis or enteritis
Flunixin meglumine (Banamine, Schering)	0.3 mg/kg PO, SC q24h ⁹ 0.5–2.0 mg/kg SC, IV q12–24h ³¹	Nonsteroidal antiinflammatory; use with caution in animals with gastritis or enteritis; use caution when using drug more than 5 days continuously; mix injectable form with palatable syrup for PO
Ibuprofen	1 mg/kg PO q12–24h ⁵⁴	Nonsteroidal antiinflammatory
Ketoprofen (Ketofen, Fort Dodge)	1 mg/kg PO, SC, IM q24h ^{9,54}	Nonsteroidal antiinflammatory; use with caution in animals with gastritis or enteritis; use caution when using drug more than 5 days continuously
Meperidine (Demerol, Winthrop-Breon)	5–10 mg/kg SC, IM, IV q2–4h ³¹	Analgesia
Morphine	0.2–2.0 mg/kg IM ¹⁴ 0.5–5.0 mg/kg SC, IM q2–6h ³¹	Analgesia
Nalbuphine (Nubain, Endo Labs)	0.5–1.5 mg/kg IM, IV q2–3h ³¹	Analgesia
Oxymorphone	0.05–0.2 mg/kg SC, IM, IV q8–12h ³¹	Analgesia
Pentazocine (Talwin, Sanofi Winthrop)	5–10 mg/kg IM q4h ³¹	Analgesia

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TABLE 61 Cardiopulmonary agents used in ferrets.

Agent	Dosage	Comments
Aminophylline	4 mg/kg PO, IM, IV q12h ⁹ 4.4–6.6 mg/kg PO, IM q12h ³⁴	Bronchodilation
Atenolol (Tenormin, ICI)	3.125–6.25 mg/kg PO q24h ⁶³ 6.25 mg/animal PO q24h ^{9,81}	β-Adrenergic blocker for hypertrophic cardiomyopathy
Atropine	0.02–0.04 mg/kg SC, IM ⁹ 0.1 mg/kg IT ⁵⁷	Bradycardia
Captopril (Capoten, Squibb)	1/8 of 12.5 mg tablet/animal PO q48h ³⁴	Vasodilator; starting dose, gradually increase to q12–24h; can cause lethargy
Digoxin (Cardoxin, Evsco)	0.005–0.01 mg/kg PO q12–24h ^{9,68} 0.01 mg/kg PO q12h, start at 75% lean BW ³⁴	Positive inotrope for dilated cardiomyopathy; monitor serum levels
Diltiazem (Cardizem, Marion Merrill Dow)	1.5–7.5 mg/kg PO q12h ^{9,81} 3.75–7.5 mg/kg PO q12h ⁶³	Calcium channel blocker for hypertrophic cardiomyopathy
Doxapram	1–2 mg/kg IV ²⁰ 5–11 mg/kg IV ⁷	Respiratory stimulant
Enalapril (Enacard, Merck)	0.25–0.5 mg/kg PO q24–48h ^{9,68,81} 1/8 of 2.5 mg tablet/animal PO q24h ³⁴	Vasodilator for dilated cardiomyopathy; do not use with concurrent renal disease ⁹
Epinephrine	0.02 mg/kg SC, IM, IV, ⁶⁶ IT	Cardiac arrest; anaphylactic reactions
Furosemide	2 mg/kg PO, SC, IM, IV q8–12h ^{34,81} 1–4 mg/kg PO, SC, IM, IV q8–12h ⁹	Diuretic
Nitroglycerin (2%) ointment (Nitrol, Savage)	1/16–1/8 inch/animal q12–24h ⁸	Vasodilator for cardiomyopathy; apply to shaved inner thigh or pinna
Propranolol (Inderal, Wyeth-Ayerst)	0.2–1.0 mg/kg PO q8–12h ³⁴ 2 mg/kg PO, SC q12h ^{7,8}	β-Blocker for hypertrophic cardiomyopathy; may cause lethargy, loss of appetite ⁸
Theophylline	4.25 mg/kg PO q8–12h ⁹	Bronchodilator; use elixir

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TABLE 62 Adrenal gland disease agents used in ferrets.

Agent	Dosage	Comments
Anastrozole (Armindex, Astrazeneca Pharmaceuticals)	0.1 mg/kg PO q24h ^{72,87}	Estrogen inhibitor; precursor hormones blocked by inhibition of aromatase enzyme; use until signs resolve, then 7 days on, 7 days off, etc.; pregnant owners should avoid handling agent
Bicalutamide (Casodex, Astrazeneca Pharmaceuticals)	5 mg/kg PO q24h ^{72,87}	Testosterone inhibitor; competitively inhibits androgen by binding to receptors in target tissues; use until clinical signs resolve, then 7 days on, 7 days off, etc.; pregnant owners should avoid handling agent
Deoxycorticosterone pivalate (DOCP)	2 mg/kg IM q21d ²⁹	Treatment of adrenal insufficiency after bilateral adrenalectomy
Flutamide (Eulexin, Schering)	10 mg/kg PO q12–24h ^{9,69}	Androgen inhibitor; useful in males with adrenal disease; reduces enlarged periurethral prostate tissue; lifetime treatment
Leuprolide acetate (Lupron, Depot 30 day, TAP)	100 µg/kg IM q4–8wk ³ 100 µg/animal <1 kg IM q4–6wk ^{37,39} 200 µg/animal >1 kg IM q4–6wk ^{37,39} 250 µg/kg IM ⁶⁴	Long-acting GnRH analog that may cause an initial stimulation then suppression of LH and FSH; palliative treatment of adrenal disease (will not resolve tumor); administer q28d until clinical signs regress, then treatment interval can be up to 6–8 wk; need to give for life of ferret; higher dosage may shrink prostate within 12–48 hr, which may improve urine flow in cases of urethral obstruction; must be prepared in aliquots and frozen until used; very expensive
Leuprolide acetate (Lupron, Depot 4 month, TAP)	2 mg/kg SC, IM q16wk ⁸⁷	
Melatonin	0.5–1.0 mg/animal q24h ⁶¹ prn	Symptomatic treatment of hyperadrenocorticism; may not affect tumor growth
Mitotane (o,p'-DDD; Lysodren, Bristol-Myers)	50 mg/animal PO q24h × 7 days, then q72h ^{32,34}	Hyperadrenocorticism; variable results and not a reliable alternative to adrenalectomy; results have been largely unsatisfactory, and therefore this agent is seldom indicated; treat until resolution of signs; may be toxic; pharmacist can prepare aliquots with cornstarch in #1 capsules ^{32,34}

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TABLE 63 Miscellaneous agents used in ferrets.^a

Agent	Dosage	Comments
Acetylsalicylic acid (aspirin)	22 mg/kg PO q24h × 3 mo ⁸²	Heartworm treatment; see thiacetarsemide (Table 58)
Activated charcoal	1–3 g/kg PO ⁶⁷	
Amantadine (Symmetrel, Endo Labs)	6 mg/kg as aerosol q12h ⁷⁴	Influenza; experimental antiviral
Aminophylline	4 mg/kg PO, IM, IV q12h ⁹	Bronchodilation
	4.4–6.6 mg/kg PO, IM q12h ³⁴	
Apomorphine	0.7 mg/kg SC ²⁶	Emetic
	5 mg/kg SC ⁷	Emetic; may cause excitation
Atropine	5–10 mg/kg ⁹ SC, IM	Organophosphate toxicity
Azathioprine (Imuran, GlaxoSmithKline)	0.9 mg/kg PO q24–72h ¹²	Immunosuppressive agent; may use in chronic hepatitis
Barium (20%)	2–5 ml/kg PO ³⁰	Gastrointestinal contrast study
	15 ml/kg PO ^{33,34}	
Bismuth subsalicylate (Pepto-Bismol, Procter & Gamble)	0.25 ml/kg PO q4–6h ^{33,34}	Gastrointestinal ulcers; may help prevent <i>Helicobacter</i> colonization ^{33,34}
	0.5–1.0 ml/kg q6–8h ⁸⁸	
	17.5 mg/kg PO q8–12h ^{27,41}	
	1/15 tablet q6–8h ⁸⁸	Mix with baby food
Bleomycin (Blenoxane, Bristol-Myers Squibb)	10 U/m ²⁸⁸	Treatment of squamous cell carcinoma
Calcium EDTA	20–30 mg/kg SC q12h ⁵⁴	Treatment of heavy metal toxicosis
Chlorpheniramine (Chlor-Trimeton, Squibb)	1–2 mg/kg PO q8–12h ^{9,34}	Antihistamine; control sneezing and coughing when they interfere with eating or sleeping ³⁴
Cimetidine (Tagamet, SmithKline)	5–10 mg/kg PO, SC, IM q8h ^{9,43}	H ₂ blocker; inhibits acid secretion; gastrointestinal ulcers; unpalatable; give IV (slow)
	10 mg/kg PO, IV q8h ^{33,34}	
Cisapride (Propulsid, Janssen)	0.5 mg/kg PO q8–12h ⁶⁵	Antiemetic; motility enhancer; not currently available in the United States
Dexamethasone	0.5–2.0 mg/kg SC, IM, IV ⁹	
	1 mg/kg IM ³⁴	Postadrenalectomy; follow with prednisone
Dexamethasone sodium phosphate	1–2 mg/kg IV ⁴	Cerebral edema therapy
	4–8 mg/kg IM, IV ⁹	Shock therapy
	6–8 mg/kg IV ³⁴	Before blood transfusion
Diazoxide (Proglycem, Medical Market Specialties)	5–30 mg/kg PO q12h ^{5,69}	Insulinoma; insulin-blocker; gradually increase to 30–60 ⁷³ –60 ^{32,34} mg/kg q24h prn; can cause hypertension, lethargy, depression, nausea ³⁴ ; some consider it minimally effective
	10 mg/kg PO q24h or divided q8–12h ^{32,34}	
	10–20 mg/kg PO q12h ⁸	

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Diphenhydramine (Benadryl, Parke-Davis)	0.5–2.0 mg/kg PO, IM, IV q8–12h ^{9,34}	Antihistamine; controls sneezing and coughing when they interfere with eating or sleeping ³⁴ ; give at high dose IM prevaccination when previous reaction encountered ⁹
Doxapram	1–2 mg/kg IV ²⁰ 5–11 mg/kg IV ⁷	Respiratory stimulant
Doxorubicin (Bedford Laboratories)	1 mg/kg IV q21d × 4 treatments	Antineoplastic agent; appears to be effective in early stages of insulinoma ^b ; premedicate with diphenhydramine (5 mg/animal SC); see Appendix 85
Epinephrine	0.02 mg/kg SC, IM, IV, ⁶⁶ IT	Severe vaccine reaction; cardiac arrest
Epoetin alfa (Epogen, Amgen)	50–150 IU/kg PO, IM q48h ⁹	Stimulates erythropoiesis; after desired PCV is reached, administer q7d for maintenance
Famotidine (Pepcid, Merck)	0.25–0.5 mg/kg PO, IV, SC q24h ⁹	Inhibits acid secretion; gastrointestinal ulcers
Fludrocortisone (Florinef, SquibbMark)	0.05–0.1 mg/kg PO q24h or divided q12h ⁵³	Mineralocorticoid replacement after adrenal gland removal
Flunixin meglumine (Banamine, Schering)	— 1 mg/kg SC, IM ²⁶ 2.5 mg/animal SC, IM q12h prn ²⁸	Nonsteroidal antiinflammatory; see Table 60 Prevention of prostaglandinmediated hypotension of endotoxemia Reduce inflammation in mastitis
Furosemide	1–4 mg/kg PO, SC, IM, IV q8–12h ⁵ 2 mg/kg PO, SC, IM, IV q8–12h ^{34,81}	Diuretic
Gonadotropinreleasing hormone (GnRH) (Cystorelin, Sanofi)	20 µg/animal SC, IM ^{32,34}	Termination of estrus after 10 day of estrus; repeat in 2 wk prn ³⁴
Hairball laxative, feline	1–2 ml/animal PO q48h ⁸	Trichobezoar prophylaxis
Heparin	100 U/animal (0.45–1.35 kg) SC q24h × 21 days ⁸² 200 U/kg SC, IM q12h × 5 days ³⁴	Heartworm treatment; see thiactarsemide (Table 58) Decreases thromboembolism; start day before heartworm adulticide treatment
Human chorionic gonadotropin (hCG) (Pregnyl, Organon)	— 50–100 IU/animal IM ²⁸ 100 IU/animal IM ^{32,34,49} 100–200 IU/animal IM ⁸ 1000 IU/animal IM ⁷⁰	Use 10 or more days after onset of estrus to induce ovulation; repeat in 1–2 wk prn ^{32,34}
Hydrocortisone sodium succinate	25–40 mg/kg IV ⁷	Shock
Hydrogen peroxide (3%)	2.2 ml/kg PO ⁶⁷	Emetic
Hydroxyzine (Atarax, Roerig)	2 mg/kg PO q8h ⁷⁹	Antihistamine; pruritus; may cause drowsiness
Insulin, NPH	0.1 IU/animal SC q12h ⁷³ 0.5–6.0 IU/kg (or to effect) SC ⁷	Diabetes mellitus; diabetic ketoacidosis; monitor blood glucose
Insulin, Ultralente	0.1 IU/animal SC q24h ⁷⁹	Diabetes mellitus; monitor blood glucose
Iohexal	0.25–0.5 ml/kg ⁴ 10 ml/kg PO ³⁰	Myelography Gastrointestinal contrast study; can dilute 1:1 with water

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Ipecac (7%)	2.2–6.6 mL/animal PO ²⁶	Emetic	
Iron dextran	10 mg/animal IM once ⁹	Iron deficiency anemia; hemorrhage	
Kaolin/pectin	1–2 mL/kg PO q2–6h prn ⁹	Gastrointestinal protectant	
Lactulose syrup (Cephulac, Merrill Dow)	0.15–0.75 mL/kg PO q12h ⁹	Absorption of blood ammonia in hepatic disease; may cause soft stools at higher dose	460
Loperamide	0.2 mg/kg PO q12h ⁹	Antidiarrheal; useful in treatment of epizootic catarrhal gastroenteritis	461
Mannitol	0.5–1.0 g/kg IV ⁴	Give over 20 min	
Metoclopramide (Reglan, Robins)	0.2–1.0 mg/kg PO, SC, IM q6–8h ⁷⁴	Antiemetic; motility enhancer	
Misoprostol (Cytotech, Searle)	1–5 µg/kg PO q8h ⁵²	Gastric ulcers	
Nutri-Cal (EVSCO)	1–3 mL/animal PO q6–8h ³⁴	Nutritional supplement	
Omeprazole (Prilosec, Astra Merck)	0.7 mg/kg PO q24h ²⁷ 4 mg/kg PO q24h ³⁵ ½ capsule/animal PO q24h × 28 days ⁵²	Proton-pump inhibitor; decreases gastric secretion of HCl <i>Helicobacter</i> ; use with clarithromycin and metronidazole <i>Helicobacter</i> ; use with clarithromycin and metronidazole	
Oxyglobin (Biopure Corp)	6–15 mL/kg IV over 4h ⁵⁸	Anemia treatment	
Oxytocin	0.2–3.0 IU/kg SC, IM ⁸ 5–10 IU/animal IM ⁷	Expels retained fetuses; stimulates lactation ⁸	
Pet-Tinic (SmithKline)	0.2 mL/kg PO q24h ³⁴	Nutritional/iron supplement for anemia	
Phenobarbital	1–2 mg/kg PO q8–12h ^{42,88} 2–10 mg/kg/hr IV constant rate infusion ⁴	Seizure control Seizure control if diazepam is not effective	
Phenoxybenzamine (Dibenzylamine, SmithKline Beecham)	3.75–7.5 mg/animal PO q24–72h ⁶⁴	α-Adrenergic antagonist; smooth muscle relaxation for urethral obstruction; potential gastrointestinal or cardiovascular side effects	
Potassium bromide	— 22–30 mg/kg/day PO ⁴ 70–80 mg/kg/day PO ⁴	Seizure control Dose if used with phenobarbital Dose if used alone	
Prazosin (Minipress, Pfizer)	0.05–0.1 mg/kg PO q8h ⁶⁴	α-Adrenergic antagonist; smooth muscle relaxation for urethral obstruction; potential for gastrointestinal and cardiovascular side effects	461
Prednisone	0.25 mg/kg PO q12h × 5 days, then 0.1 mg/kg q12h × 10 days ³⁴ 0.25–1.0 mg/kg PO divided q12h ^{32,34} 0.5 mg/kg PO q12h × 7–10 days, then q24h × 7–10 days, then q48h × 7–10 days ⁵⁶ 0.6 mg/kg PO q24h ⁷ 1 mg/kg PO q24h × 7–14 days ³⁴ 1.25–2.5 mg/kg PO q24h ⁵⁹ 2 mg/kg PO q24h ⁸⁸ 2.2 mg/kg ⁸⁸	Postoperative adrenalectomy; after initial dose of dexamethasone Insulinoma; gradually increase to 4 mg/kg/day prn; up to 2 mg/kg/day when given with diazoxide ^{32,34} Postoperative adrenalectomy Gradually taper dose Use after heartworm adulticide treatment; thromboembolism Eosinophilic gastroenteritis; treat until clinical signs abate; gradually decrease to q48h ⁵⁹ Palliative therapy for lymphosarcoma Antiinflammatory for chronic inflammatory bowel disease	462
Prednisolone sodium succinate	22 mg/kg IV ³⁴	Before blood transfusion; give slowly	

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Prostaglandin F ₂ -α (Lutalyse, Upjohn)	0.1–0.5 mg/animal IM prn ^{8,9} 0.5 mg/animal IM ⁶	Metritis; expels necrotic debris Can induce delivery on day 41 if only one kit; follow with 6 units oxytocin 1–4 hr later
Ranitidine HCl (Zantac, Glaxo Wellcome)	3.5 mg/kg PO q12h ¹³	Inhibits acid secretion; gastrointestinal ulcers
Ranitidine bismuth citrate (Pylorid, Glaxo Wellcome)	24 mg/kg PO q8h ⁴⁵	<i>Helicobacter</i> ; use in combination with clarithromycin; not available in the United States
Saw palmetto	0.15 ml/animal PO q12h ⁸⁰	Homeopathy remedy used for dysuria associated with prostatic enlargement
Stanozolol (Winstrol, Upjohn)	0.5 mg/kg PO, SC q12h ⁸	Anemia; anabolic steroid; use with caution in hepatic disease
Sucralfate (Carafate, Hoechst Marion Roussel)	25 mg/kg PO q8h ⁴³ 25–125 mg/kg PO q8–12h ⁴² 75 mg/kg PO q4–6h ⁸⁸ 100 mg/kg PO q8–12h ¹³ 1/8 of 1 g tablet/animal PO q6h ^{33,34}	Gastrointestinal ulcers, give before meals; requires acidic pH
Theophylline elixir	4.25 mg/kg PO q8–12h ⁹	Bronchodilator
Ursodiol (Actigall, Ciba)	15 mg/kg PO q12h ¹²	Treatment of chronic hepatopathies
Vitamin B complex	1–2 mg/kg IM prn ⁹	Dose based on thiamine content
Vitamin K	—	Use feline dosage ⁵²
Yeast, brewer's	1/8–1/4 tsp PO q12h ³⁴	Source of chromium to stabilize glucose and insulin for animals with insulinomas

a See [Appendix 85](#) for chemotherapy protocols for lymphoma.

b Dutton MA. Personal communication. 2004.

APPENDIX 79 Hematologic values of ferrets.^{23,86}

Measurements	Albino Ferrets		Fitch Ferrets	
	Male	Female	Male	Female
PCV (%)	55 (44–61)	49 (42–55)	43 (36–50)	48 (47–51)
RBC (10 ⁶ /μl)	10.2 (7.3–12.2)	8.1 (6.8–9.8)	—	—
Hb (g/dl)	17.8 (16.3–18.2)	16.2 (14.8–17.4)	14.3 (12.0–16.3)	15.9 (15.2–17.4)
WBC (10 ³ /μl)	9.7 (4.4–19.1)	10.5 (4.0–18.2)	11.3 (7.7–15.4)	5.9 (2.5–8.6)
Neutrophils (%)	57 (11–82)	60 (43–84)	40 (24–78)	31 (12–41)
Band cells (%)	—	—	0.9 (0–2.2)	1.7 (0–4.2)
Lymphocytes (%)	36 (12–54) ^a	33 (12–50)	50 (28–69)	58 (25–95)
Monocytes (%)	4 (0–9)	4 (2–8)	6.6 (3.4–8.2)	4.5 (1.7–6.3)
Eosinophils (%)	2 (0–7)	3 (0–5)	2 (0–7)	4 (1–9)
Basophils (%)	0.1 (0–2)	0.2 (0–1)	0.7 (0–2.7)	0.8 (0–2.9)
Platelets (10 ³ /μl)	453 (297–730)	545 (310–910)	—	—
Reticulocytes (%)	4 (1–12)	5 (2–14)	—	—

a May be as high as 75% in young ferrets.³⁶

APPENDIX 80 Serum biochemical values of ferrets. ^{23,38,86}

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Measurements	Albino Ferrets	Fitch Ferrets
ALT (IU/L)	—	170 (82–289)
AP (IU/L)	23 (9–84)	53 (30–120)
AST (IU/L)	65 (28–120)	—
Bilirubin, total (mg/dl)	<1	—
BUN (mg/dl)	22 (10–45)	28 (12–43)
Calcium (mg/dl)	9.2 (8.0–11.8)	9.3 (8.6–10.5)
Carbon dioxide (mEq/L)	—	25 (20–28) ^a
Chloride (mEq/L)	116 (106–125)	115 (102–121)
Cholesterol (mg/dl)	165 (64–296)	—
Creatinine (mg/dl)	0.6 (0.4–0.9)	0.4 (0.2–0.6)
GGT (IU/L)	—	5
Glucose (mg/dl)	136 (94–207)	101 (63–134)
LDH (IU/L)	—	460 (241–752) ^a
Lipase (U/L)	—	0–200
Phosphorus (mg/dl)	5.9 (4.0–9.1)	6.5 (5.6–8.7)
Potassium (mEq/L)	5.9 (4.5–7.7)	4.9 (4.3–5.3)
Protein, total (g/dl)	6.0 (5.1–7.4)	5.9 (5.3–7.2)
Albumin (g/dl)	3.2 (2.6–3.8)	3.7 (3.3–4.1)
Globulin (g/dl)	—	2.2 (2.0–2.9) ^a
Albumin/globulin	—	1.8 (1.3–2.1) ^a
Sodium (mEq/L)	148 (137–162)	152 (146–160)
Triglycerides (mg/dl)	—	18 (10–32) ^a

a From males only; cardiac sample.

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APPENDIX 81 Biologic and physiologic data of ferrets. ^{23,46,55,76}

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Parameter	Normal Values
Adult body weight, female	1–2 kg
Adult body weight, male	0.5–1 kg
Birth weight	6–12 g
Sexual maturity	4–8 mo (usually first spring after birth)
Reproductive cycle	Induced ovulator
Gestation period	42 ± 2 days
Litter size	1–18 (average, 8; primiparous jill, 10)
Weaning age	6–8 wk
Eyes open	34 days
Hearing	32 days
Life span	5–8 yr (average in United States)
Food consumption	43 g/kg/day
Water consumption	75–100 ml/day
Gastrointestinal transit time	3–4 hr
Dental formula	2(I 3/3 C 1/1 P 3/3 M 1/2) = 34
Heart rate	200–400 beats/min
Respiratory rate	33–36 breaths/min
Rectal temperature	37.8° C–40.0° C (100.0° F–104.0° F)
Blood volume	60–80 ml (5%–7% body weight)
Intraocular pressure	22.8 ± 5.5 mm Hg
Prothrombin time	8.0–16.5 sec
Partial thromboplastin time	16–25 sec

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APPENDIX 82 Urinalysis values of ferrets. ^{65,86}

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Parameter	Male	Female
Volume (ml/24 hr)	26 (8–48)	28 (8–140)
Sodium (mmol/24 hr)	1.9 (0.4–6.7)	1.5 (0.2–5.6)
Potassium (mmol/24 hr)	2.9 (1.0–9.6)	2.1 (0.9–5.4)
Chloride (mmol/24 hr)	2.4 (0.7–8.5)	1.9 (0.3–7.8)
pH	6.5–7.5 ^a	6.5–7.5 ^a
Protein (mg/dl)	7–33	0–32
Exogenous creatinine clearance (ml/min/kg) ^b	—	3.32 ± 2.16
Insulin clearance (ml/min/kg)	—	3.02 ± 1.78

a Urine pH can vary according to diet; normal urine pH in ferrets on a high-quality, meat-based diet is approximately 6.0.

b Endogenous creatinine clearance (ml/min/kg) = 2.50 ± 0.93.

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APPENDIX 83 Proposed schedule of vaccinations and routine prophylactic care for ferrets. ^{8,13,15,75,85}

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Age	Recommendation
4–6 wk	CDV ^a vaccination if dam is unvaccinated
6–8 wk	CDV ^{a,b} vaccination; physical examination; fecal examination
10–11 wk	CDV ^{a,b,c} vaccination; physical examination; fecal examination
12–14 wk	CDV ^{a,b,c} vaccination; rabies vaccination ^d ; physical examination; fecal examination (optional) ^e
4–6 mo	Spay/castrate (some recommend these surgeries between 6–8 mo of age); fecal examination; remove musk glands (optional) ^e
1 yr	CDV ^{a,f} booster; rabies booster ^d ; physical examination including dental prophylaxis; fecal examination if indicated; CBC ^e
2 yr	CDV ^{a,f} booster; rabies booster ^d ; physical examination including dental prophylaxis; fecal examination if indicated; CBC ^e
3 yr and older (every 6 mo)	CDV ^{a,f} booster (annual); rabies booster ^d (annual); physical examination including dental prophylaxis; fecal examination if indicated; CBC; serum chemistries, including fasting blood glucose ^e

- a CDV, Canine distemper vaccine; Purevax (Merial) and Fervac-D (United Vaccine) are the only CDV vaccines approved for use in ferrets; although not approved for use in ferrets, Galaxy-D (Solvay) has also been used.
- b Purevax is recommended to be administered at 8 wk then every 3 wk for 3 doses.
- c Vaccinations are generally administered at 2–3 wk intervals until the ferret is 12–14 wk of age.
- d Only a killed virus vaccine (Imrab 3, Rhône Merieux) should be used.
- e Heartworm prevention may be indicated in ferrets in endemic areas.
- f In previously unvaccinated adults, an initial series of two vaccinations given 14–28 days apart should be given.

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APPENDIX 84 Clinical signs and treatment of ferret endocrine diseases.^{40,53}

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Disease	Clinical Signs	Sex/Age Predilection
Hyperestrogenism (generally related to protracted estrus/ovarian remnant; also see adrenocortical disease)	<ul style="list-style-type: none"> Severity varies: pale mucous membranes, vulvar enlargement, weakness, anorexia, weight loss, alopecia of tail and abdomen, melena, petechiation Systolic murmur, weak pulses, posterior paresis, and systemic infections as disease progresses Progression of disease slower in adrenocortical vs. protracted estrus/ovarian remnant-related disease 	<ul style="list-style-type: none"> Can occur after protracted estrus (i.e., >3 wk) Can occur in spayed ferrets if remnant ovarian tissue present
Adrenocortical disease (hyperadrenocorticism)	<ul style="list-style-type: none"> See hyperestrogenism Bilaterally symmetric alopecia starting on tail and progressing cranially Vulvar enlargement in >90% of spayed females with this disease Occasional pruritus Prostatomegaly (resulting in dysuria, anuria) Adrenal gland(s) may be palpably enlarged (left gland more commonly affected) 	<ul style="list-style-type: none"> Adult spayed females and neutered males; one report in intact ferret Average age of onset 2–4 yr
Pancreatic endocrine neoplasia (insulinoma)	<ul style="list-style-type: none"> Episodic weakness, lethargy, hypersalivation, ataxia, posterior paresis, seizures Episodes frequently follow periods of exercise or fasting 	<ul style="list-style-type: none"> No reported sex predilection Usually >3 yr of age
Diabetes mellitus	<ul style="list-style-type: none"> Some unpublished reports in domestic ferrets Polyuria, polydipsia, polyphagia, dehydration, weight loss 	<ul style="list-style-type: none"> Unknown

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Disease	Diagnostic Indicators	Treatment	Prognosis	
Hyperestrogenism	<ul style="list-style-type: none"> • Nonregenerative anemia • Thrombocytopenia • Leukopenia 	<ul style="list-style-type: none"> • Supportive care and ovariectomy, or surgical excision of remnant ovarian tissue • Some recommend initial conservative medical treatment (e.g., hCG, GnRH, supportive care) before surgery 	<ul style="list-style-type: none"> • Fair to good if PCV >20% • Guarded if PCV 14%–19% • Grave if PCV <14% 	470
Adrenocortical disease	<ul style="list-style-type: none"> • CBC, biochemistry parameters usually within normal limits • Enlarged adrenal glands are rarely seen radiographically • Ultrasonography can be diagnostic in most cases • Elevated serum estradiol, androstenedione, and 17-OH progesterone are diagnostic • Although seldom needed, skin biopsy may show signs consistent with endocrine disease (hyperkeratosis, epidermal thinning) • ACTH stimulation and dexamethasone suppression tests not diagnostic 	<ul style="list-style-type: none"> • Adrenalectomy of affected gland if unilateral; complete removal of larger gland and debulking of smaller gland if bilateral disease; right adrenal gland difficult to remove; bilateral adrenalectomies have been performed with encouraging results • Leuprolide or melatonin may decrease clinical signs but will not alter tumor growth; mitotane is not a reliable treatment 	<ul style="list-style-type: none"> • Histologic diagnoses are generally adrenocortical adenoma or hyperplasia, rarely, adenocarcinoma • Prognosis good with adrenalectomy • Metastasis is rare 	470
Insulinoma	<ul style="list-style-type: none"> • Blood glucose \leq60–70 mg/dl (and frequently much lower) on multiple samples • CBC, biochemistry values (except glucose), radiographs, and ultrasound usually within normal limits • Blood insulin concentrations are not reliable, but values above 250–300 pmol/L are probably abnormal 	<ul style="list-style-type: none"> • Objective is to achieve euglycemia • Combination of surgical excision of pancreatic nodules and medical therapy (e.g., prednisone) usually required for optimal stabilization • Client compliance critical for effective home management 	<ul style="list-style-type: none"> • Stabilization possible with treatment, but disease is usually chronic and eventually fatal • Tendency is to slowly metastasize (primarily within pancreas) 	471
Diabetes mellitus	<ul style="list-style-type: none"> • Hyperglycemia, glycosuria, ketonuria 	<ul style="list-style-type: none"> • Insulin (follow feline protocols) 	<ul style="list-style-type: none"> • Fair with treatment 	471

APPENDIX 85 Chemotherapy protocols for lymphoma in ferrets.^a

Protocol I ^{8,53,89}			
Week	Day	Agent	Dosage
1	1	Prednisone	1–2 mg/kg PO q12h and continued throughout therapy
	1	Vincristine	0.025 mg/kg IV
	3	Cyclophosphamide	10 mg/kg PO, SC
2	8	Vincristine	0.025 mg/kg IV
3	15	Vincristine	0.025 mg/kg IV
4	22	Vincristine	0.025 mg/kg IV
	24	Cyclophosphamide	10 mg/kg PO, SC
7	46	Cyclophosphamide	10 mg/kg PO, SC
9	63	Prednisone	Gradually decrease dose to 0 over the next 4 wk

Protocol II ^{b,53,68,89}			
Week	Agent	Dosage	
1	Vincristine	0.025 mg/kg IV	
	Asparaginase	400 IU/kg IP	
	Prednisone	1 mg/kg PO q24h and continued throughout therapy	
2	Cyclophosphamide	10 mg/kg SC	
3	Doxorubicin	1 mg/kg IV	
4–6	As weeks 1–3 above, but discontinue asparaginase	—	
8	Vincristine	0.025 mg/kg IV	
10	Cyclophosphamide	10 mg/kg SC	
12	Vincristine	0.025 mg/kg IV	
14	Methotrexate	0.5 mg/kg IV	

a CBC should be checked weekly during therapy; after therapy is discontinued, continue to monitor CBC and do physical examination at 3-mo intervals.

b Protocol is continued in sequence biweekly after week 14, making the therapy protocol less intensive.

9.1 APPENDIX 86 Literature cited—ferrets.

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Miniature Pigs

Valarie V. Tynes, DVM, Diplomate ACVB

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TABLE 64 Antimicrobial agents used in miniature pigs.^a

Agent	Dosage	Comments
Amoxicillin	10 mg/kg PO q12h ²¹	
Amoxicillin/clavulanate (Clavamox, Pfizer)	11–13 mg/kg PO q24h ⁸	
Ampicillin		
Sodium	10–20 mg/kg IV q6–8h ¹⁰	
Trihydrate	4.4–22 mg/kg IM q8–12–24h ⁸	
Apramycin (Apralan, Elanco)	10–20 mg/kg PO q12–24h ⁸	
Ceftiofur (Naxcel, Pharmacia & Upjohn)	3–10 mg/kg IM q24h ⁸	
	1.1–2.2 mg/kg q24h × 7 days ⁵	Rhinitis
Ceftriaxone (Rocephlin, Roche)	50–75 mg/kg IM, IV q24h ²¹	
Cephalexin	20 mg/kg PO q12h ²²	
Cephradine	25–50 mg/kg PO q12h ²¹	
Enrofloxacin (Baytril, Bayer)	2.5–5.0 mg/kg IM q24h ⁸	
Gentamicin	2–4 mg/kg IM q8–12h ⁸	
Lincomycin	10 mg/kg IM q24h ⁸	
Metronidazole	66 mg/kg PO q24h ²¹	
Neomycin	7–12 mg/kg PO q12h ¹⁰	
	10 mg/kg PO q6h ⁸	
Oxytetracycline	6.6–11 mg/kg IM, IV q24h ¹⁰	
Long-acting formulation	20 mg/kg IM q72h ¹⁰	
	100 mg/animal on day 1, then 200 mg q7d × 3 treatments ⁵	Rhinitis
Penicillin G, procaine	20,000–45,000 IU/kg IM q24h ⁸	
Penicillin G (procaine/benzathine combination)	20,000–60,000 IU/kg IM q24h ¹⁰	
Spectinomycin (Spectam, Merial)	6.6–22 mg/kg PO q24h ¹⁰	
Trimethoprim/sulfa	5 mg/kg IM q24h ²¹	
	25–50 mg PO q24h ²¹	
Tylosin (Tylan, Elanco)	5.0–8.8 mg/kg ⁵ IM	
	8.8 mg/kg IM q24h ¹⁰	

^a Not to be used in animals for human consumption.

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TABLE 65 Antiparasitic agents used in miniature pigs.^a

Agent	Dosage	Comments
Dichlorvos	20 mg/kg PO ¹	
Fenbendazole	10 mg/kg PO q24h × 3 days ⁵	Whipworms
Ivermectin	0.3 mg/kg PO, SC, IM ⁵	Repeat in 10–14 days for sarcoptic mange
Levamisole	10 mg/kg PO ¹	
Metronidazole	66 mg/kg PO q24h ²¹	
Piperazine	200 mg/kg PO ¹	
Pyrantel	6.6 mg/kg PO, repeat prn ⁵	
Sulfadimethoxine	25 mg/kg PO ¹	

^a Not to be used in animals for human consumption.

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TABLE 66 Chemical restraint/anesthetic/analgesic agents used in miniature pigs.^a

Agent	Dosage	Comments
Acepromazine	—	See ketamine for combination
	0.03–0.10 mg/kg IM ⁵	Facilitates catheter placement
	0.1–0.2 mg/kg IM ⁵	Calms sow to allow nursing
	0.2–1.1 mg/kg IM ⁵	Tranquilization
Aspirin	10 mg/kg PO q12h ⁹	Analgesia; antiinflammatory; antipyretic; enteric coated
Atropine	—	See detomidine for combination
	0.04 mg/kg SC, IM, IV ⁶	Preanesthetic; bradycardia; hypersalivation
Azaperone (Stresnil, Schering-Plough)	0.25–0.50 mg/kg IM ⁵	Relaxation, sedation, without ataxia
	2 mg/kg IM ⁵	Sedation, with ataxia
	2.2 mg/kg IM ⁵	Calms sow to allow nursing
	2–8 mg/kg IM ^{6,9}	Sedation; immobilization
Buprenorphine (Buprenex, Reckitt & Colman)	0.005–0.010 mg/kg IM, IV q12h ⁹	Analgesia
	0.05–0.10 mg/kg IM, IV q8–12h ²¹	Analgesia
Butorphanol (Torbugesic, Fort Dodge)	—	See detomidine, ketamine for combinations
	0.05–0.20 mg/kg SC, IV q3–4h ⁹	Analgesia
	0.1–0.3 mg/kg IM, IV q8–12h ²¹	Analgesia
Detomidine (Dormosedan, Pfizer) (D)/butorphanol (B)/midazolam (M)/atropine (A)	(D) 0.125 mg/kg + (B) 0.3 mg/kg + (M) 0.3 mg/kg + (A) 0.06 mg/kg IM ⁶	Anesthesia; reverse detomidine with yohimbine or atipamezole, and reverse butorphanol with naloxone; can reverse midazolam with flumazenil, if needed
Diazepam	—	See ketamine for combination
	0.5–1.5 mg/kg IV ²²	Sedation
	0.5–3.0 mg/kg IM ⁴	Sedation
	0.5–8.5 mg/kg IM ⁶	Sedation
Droperidol	—	See fentanyl/droperidol
	0.1–0.4 mg/kg IM ^{5,6}	Tranquilization; minor procedures
Fentanyl/droperidol (Innovar-Vet, Schering-Plough)	1 ml/9–14 kg IM ²⁶	Sedation; maximum effect in 20 min
	1 ml/12–25 kg IM ⁵	Tranquilization; minor procedures
Flumazenil (Romazicon, Hoffman-LaRoche)	1 mg/10–15 mg midazolam IM, IV ⁶	Midazolam reversal
Flunixin meglumine (Banamine, Schering-Plough)	0.5–1.0 mg/kg SC, IV q12–24h ⁹	Analgesia
Glycopyrrolate (Robinul-V, Fort Dodge)	0.005–0.010 mg/kg SC, IM, IV ⁶	Preanesthetic; bradycardia; hypersalivation
Guaifenesin (G)/ketamine (K)/xylazine (X)	0.5–1.0 ml/kg IV to effect ¹¹	Combination prepared by using (G) (5%) with (K) (1–2 mg/ml) and (X) (1 mg/ml); induction; maintain at 2.2 ml/kg/hr
Halothane	4%–5% induction ^{5,12} or to effect ²⁶	
Isoflurane	4%–5% induction ^{5,12} or to effect ²⁶	Recommended for sick or debilitated pigs and for those <8 wk of age

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Ketamine	—	Ketamine combinations follow; see guaifenesin, tiletamine/zolazepam for combination	
	—	Poor muscle relaxation; poor visceral analgesia; rough recovery, especially IM; use with other agents ⁵	
Ketamine (K)/acepromazine (A)	(K) 10–20 mg/kg + (A) 0.05–0.50 mg/kg IM ⁶	Anesthesia	
Ketamine (K)/diazepam (D)	—	Short-term anesthesia; prolong with (K) 2–4 mg/kg IV prn; no analgesia; smoother recovery than ketamine alone	
	(K) 10–18 mg/kg + (D) 1–2 mg/kg IM ²⁶		
	(D) 1–2 mg/kg IM, then (K) 12–20 mg/kg IM ⁵		
Ketamine (K)/xylazine (X)	(K) 1–2 mg/kg + (X) 0.5 mg/kg IV ¹¹	Tranquilization	
	(K) 1.5 mg/kg + (X) 0.75 mg/kg IV ¹¹	Sedation for cesarian section, with local anesthetic at incision	
	(K) 2 mg/kg + (X) 2 mg/kg IV ¹¹	Sedation	
	(K) 5–20 mg/kg + (X) 1–2 mg/kg IM ⁶	Anesthesia; rough recovery	
	(X) 2.2 mg/kg IM, then (K) 12–20 mg/kg IM ⁵	Short-term anesthesia; prolong with (K) 2–4 mg/kg IV prn	482
Ketamine (K)/xylazine (X)/butorphanol (B)	(K) 11 mg/kg + (X) 2 mg/kg + (B) 0.22 mg/kg IM ⁶	Anesthesia; butorphanol enhances analgesia	483
Meperidine (Demerol, Winthrop-Breon)	2–10 mg/kg IM q4h ⁹	Analgesia	
Midazolam (Versed, Roche)	—	See detomidine for combination	
	0.1–0.5 mg/kg ²¹ IM	Sedation	
Morphine	0.2 mg/kg IM q4h ⁹	Analgesia	
Naloxone (P/M Naloxone, Schering-Plough)	4 mg total dose IV ⁶	Narcotic reversal	
Nitrous oxide	—	Nitrous oxide and oxygen at equal levels (1–2 L/min) before isoflurane induction; may help calm animal during mask induction ²²	
Pentazocine (Talwin-V, Pharmacia & Upjohn)	2 mg/kg IM q4h ⁹	Analgesia	
Phenylbutazone	4–8 mg/kg PO q12h ²¹	Antiinflammatory; analgesia; antipyretic	
Promazine hydrochloride	0.4–1.0 mg/kg IV ¹¹	Tranquilization	
	0.5–2.0 mg/kg IM ¹¹	Tranquilization	
Thiamylal	1.5–2.5 mg/kg IV ¹¹	Induction	
Tiletamine/zolazepam (Telazol, Fort Dodge)	—	Tiletamine/zolazepam combinations follow	
	—	Poor muscle relaxation; may cause rough recovery ⁵	
	4–6 mg/kg IM ^{6,9}	Sedation; immobilization	
Tiletamine/zolazepam (T)/ketamine (K)/xylazine (X)	—	Reconstitute Telazol (500 mg) with 2.5 ml ketamine (100 mg/ml) and 2.5 ml 10% xylazine (100 mg/ml) instead of water; mixture has 50 mg/ml each of tiletamine, zolazepam, ketamine, xylazine	
	0.006–0.013 ml/kg IM ¹²	Tranquilization; sedation	
	0.020–0.026 ml/kg IM ¹²	Before intubation; surgical anesthesia	
	0.022–0.044 ml/kg IM ⁵	Induction; maintain with 0.022 ml/kg IV prn	483

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Tiletamine/Zolazepam (T)/xylazine (X)	—	Anesthesia; rapid induction; poor muscle relaxation; may have rough recovery Anesthesia duration of 30–40 min	484
	(T) 2 mg/kg + (X) 2 mg/kg IV ⁵		
	(X) 2.2 mg/kg, then (T) 2–4 mg/kg IM ¹¹		
	(T) 6 mg/kg + (X) 2.2 mg/kg IM ^{5,6}		
Xylazine	—	See guaifenesin, ketamine, tiletamine/zolazepam for combinations Sedation; tranquilization; deep sedation seldom encountered	
	0.5–3.0 mg/kg IM ⁴		
Yohimbine (Antagonil, Wildlife Laboratories)	0.125–0.3 mg/kg IV ^{5,6}	Xylazine and detomidine reversal	
a Not to be used in animals for human consumption.			

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TABLE 67 Miscellaneous agents used in miniature pigs.^a

Agent	Dosage	Comments
Attapulgit (Kaopectate, Upjohn)	2.2 ml/kg PO ¹	Gastrointestinal protectant; diarrhea
Dantrolene sodium (Dantrium, Proctor & Gamble)	2–5 mg/kg PO, IV q8h ⁷	Malignant hyperthermia
Gleptoferrin	25 mg/animal IM ¹³ in first few days of life, may repeat in 2–3 wk ⁵	Iron deficiency in baby pigs; uncommon in miniature pigs
Glucose	—	Hypoglycemic neonate
	20–40 ml/kg of 5% solution IP ⁵	
	10–20 ml/kg of 10% solution IP ⁵	
Hydrogen peroxide	1 ml/5 kg PO ²²	Induces vomiting; some animals may require larger dose
Ipecac syrup	7–15 ml/animal PO ²²	Induces vomiting
Iron dextran	25 mg/animal IM ¹³ in first few days of life, may repeat in 2–3 wk ⁵	Iron deficiency in baby pigs; uncommon in miniature pigs
Oxytocin	10–20 IU/animal ³ IM	Dystocia, if not obstructed
Prostaglandin F ₂ -α (Lutalyse, Pharmacia & Upjohn)	5 mg/animal ³ IM	Induces parturition in 24–30 hr when given within 3 days of expected parturition; causes abortion after 12 days of gestation
Ranitidine (Zantac, Glaxo Wellcome)	150 mg/animal PO q12h ¹	Antisecretory for gastric acid

a Not to be used in animals for human consumption.

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APPENDIX 87 Hematologic and serum biochemical values of miniature pigs.¹⁶

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Measurement	Mean (reference range) ^a
HEMATOLOGY	
PCV (%)	45 (36–53)
RBC ($10^6/\mu\text{l}$)	7.0 (5.4–8.6)
Hb (g/dl)	14.9 (12.5–17.3)
MCH (pg)	21.4 (18.8–24.0)
MCHC (g/dl)	33.2 (31.6–34.8)
MCV (fl)	64 (57–72)
Platelets ($10^3/\mu\text{l}$)	441 (201–680)
WBC ($10^3/\mu\text{l}$)	12.6 (6.6–18.6)
Neutrophils (%)	42 (18–66)
Band cells (%)	0.2 (0.0–1.2)
Lymphocytes (%)	46 (19–72)
Monocytes (%)	8 (1–13)
Eosinophils (%)	4 (0–10)
Basophils (%)	0.5 (0.0–2.5)
CHEMISTRIES	
ALT (IU/L)	34 (20–47)
AST (IU/L)	28 (10–56)
Bilirubin, total (mg/dl)	0.1 (0.0–0.3)
BUN (mg/dl)	19 (9–29)
Calcium (mg/dl)	10.6 (9.6–11.6)
Chloride (mEq/L)	104 (94–114)
Cholesterol (mg/dl)	102 (38–165)
CPK (IU/L)	168 (48–288)
Creatinine (mg/dl)	1.6 (1.2–2.0)
Glucose (mg/dl)	80 (36–123)
Phosphorus (mg/dl)	6.9 (5.1–8.1)
Potassium (mEq/L)	4.6 (4.0–5.2)
Protein, total (g/dl)	7.5 (6.1–8.9)
Albumin (g/dl)	4.7 (3.9–5.5)
Globulin (g/dl)	2.8 (1.6–4.0)
A:G ratio	1.8 (0.8–2.8)
Sodium (mEq/L)	147 (144–153)

a n = 30 healthy, mature Yucatan miniature pigs.

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APPENDIX 88 Biologic and physiologic data of miniature pigs.²⁻⁵

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Parameter	Values
Life expectancy	20–25 years (average, 10–15) ¹⁴
Respiratory rate (beats/min)	
Newborn	50–60
Weaned pigs	25–40
10–15 wk	30–40
15–26 wk	25–35
Sows, boars	13–18
Heart rate (beats/min)	
Newborn	200–250
Weaned pigs	90–100
10–15 wk	80–90
15–26 wk	75–85
Sows, boars	70–80
Rectal temperature ¹⁵	34.8° C–39.1° C (94.6° F–102.4° F); diurnal variation in body temperature exists; temperature decreases as age increases
Weight	
Birth	250–450 g
Adult ²³	Avg, 55 kg; range, 34–91 kg (avg, 120 lb; range, 75–200 lb)
Reproduction	
Puberty	
• Boars	3 mo of age
• Gilts	3.5–4.0 mo of age
Estrous cycle	18–24 (avg, 21) days
Standing heat duration	1–3 days
Ovulation	
• Gilts	24–36 hr after onset of estrus
• Sows	30–44 hr after onset of estrus
Gestation length	112–116 (avg, 114) days
Litter size	4–15 (avg, 6–8) piglets

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APPENDIX 89 Blood collection sites in miniature pigs.^{20,22,25}

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Venipuncture Site	Comments
Cranial vena cava	Anesthesia required for safety
Right brachiocephalic vein	Most pigs will require anesthesia
Right external jugular vein	Easier if pig is anesthetized
Cephalic vein	Thick skin makes this difficult; cut down may be required; good choice for catheterization for fluid or medication administration
Lateral auricular vein	Easiest in debilitated or very cooperative pigs; good for obtaining small blood samples; can use for catheterization but more difficult to maintain
Subcutaneous abdominal vein	Easy to visualize and access, even in conscious pigs

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APPENDIX 90 Preventive medicine recommendations for miniature pigs. ^{14,17–19,24}

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Minimum recommended vaccinations		
Pet pigs		
Erysipelas		8–12 wk of age; repeat in 3 wk; revaccinate semiannually or annually
Leptospirosis		8–12 wk of age; repeat in 3 wk; revaccinate semiannually or annually
Pneumonia (<i>Actinobacillus pleuropneumoniae</i>)		8–12 wk of age; repeat in 3 wk; revaccinate semiannually or annually
Breeder pigs		
Erysipelas		8–12 wk of age; repeat in 3 wk; revaccinate 3 wk before breeding
Leptospirosis		8–12 wk of age; repeat in 3 wk; revaccinate 3 wk before breeding
Parvovirus		5–6 mo of age; repeat in 3 wk; revaccinate 3–8 wk before breeding; boars should be revaccinated semiannually
Pneumonia (<i>A. pleuropneumoniae</i>)		Sows: 5 and 2 wk before farrowing
		Piglets: 3–8 wk of age; repeat in 3 wk
Selected disease vaccinations		
Colibacillosis (baby pig scours) (<i>Eschericia coli</i>)		Sows: 5 and 2 wk before first farrowing and 2 wk before each subsequent farrowing
Other enteritides (rotavirus, TGE virus, <i>Clostridium</i> , <i>Salmonella</i>)		Sows: 5 and 2 wk before farrowing
Atrophic rhinitis (<i>Bordetella bronchiseptica</i> , <i>Pasteurella multocida</i> [types A and D])		Sows: 7 and 3 wk before first farrowing and 3 wk before each subsequent farrowing
		Piglets: 1 wk of age; repeat in 3 wk
Pneumonia (<i>Mycoplasma hyopneumoniae</i>)		Boars: semiannually or annually Sows: 5 and 2 wk before first farrowing and 2 wk before each subsequent farrowing
		Piglets: 1 wk of age; repeat in 2–3 wk
Swine influenza		Boars: semiannually or annually 8–12 wk of age; repeat in 3 wk; revaccinate annually
Tetanus toxoid		Vaccinate after surgery or trauma when exposure exists
Neonatal care		
Preferred environmental temperature at 1–7 days of age		33° C–35° C (92° F–95° F); may be lowered 1.7° C–2.8° C (3° F–5° F) each wk for 4–6 wk until weaned
Colostrum		15–20 ml in 2–3 feedings within first 12 hr of life
Iron dextran or gleptoferrin supplementations		25 mg/animal IM ¹³ at 1 day of age; may repeat at 3 wk of age
Other care		Cut umbilical cord and dip in tincture of iodine; trim needle teeth (canines) at 1 day of age
Castration		<3 mo of age
Ovariohysterectomy/ovariectomy		3–4 mo of age but may be performed as early as 6 wk of age

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Tusk (canine) removal	Not recommended
Tusk (canine) trimming	As needed
Fecal examination	
Young (6 wk to 6 mo of age)	Bimonthly
Adults	Biannually (minimum)

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10.1 APPENDIX 91 Literature cited—miniature pigs

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 Primates

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TABLE 68 Antimicrobial and antifungal agents used in primates.

Agent	Dosage	Species/Comments
Amikacin	2.3 mg/kg IM q24h ^{43,111}	Lemurs
Amoxicillin	11 mg/kg PO q12h ²³ 11 mg/kg SC, IM q24h ²³	
Amoxicillin trihydrate, clavulanic potassium	6.5–13.5 mg/kg PO q8h ⁸ 15 mg/kg PO q12h ¹⁰³ 62.5 mg PO q12h ⁷⁵	Macaques Lemurs
Amphotericin B	0.25–1.0 mg/kg IV q24h ⁴⁴	
Ampicillin	20 mg/kg PO, IM, IV q8h ⁴⁴ 50–100 mg/kg IM q12h × 7–10 days ⁴³	
Azithromycin	25–50 mg/kg SC q24h × 7 days ⁸³ 40 mg/kg IM, SC q24h, followed by 20 mg/kg q24h days 2–5 ⁸	Macaques/antimalarial activity
Cefazolin sodium	25 mg/kg IM, IV q12h × 7–10 days ⁴³	
Cefotaxime (Claforan, Hoechst Marion Roussel)	50 mg/kg IM, IV q8h ^{8,30} 100–200 mg/kg IV q6–8h ⁸⁰	
Ceftazidime	50 mg/kg IM, IV q8h ¹⁶	Lemurs
Ceftizoxime (Cefizox, Fujisawa)	75–100 mg/kg IM q12h × 7 days ⁴³	
Ceftriaxone (Rocephin, Roche)	10 mg/kg IV ¹⁰⁰ 50–100 mg/kg IM, IV q12–24h ⁸⁰	Macaques, chimpanzees/PD Great apes/bacterial meningitis; excellent penetration into cerebrospinal fluid; transient, self-limiting diarrhea is a side effect
Cephalexin	20 mg/kg PO q12h ¹⁸	
Cephaloridine	20 mg/kg IM q12h ¹⁸	
Cephalothin	25 mg/kg IM q12h ⁹³	
Chloramphenicol palmitate	50 mg/kg PO q12h ¹⁸	
Chloramphenicol sodium succinate	20 mg/kg IM q12h ²³ 50–100 mg/kg SC, IM, IV q8h ^{33,44} 110 mg/kg IM q6h × 5–10 days ³³	Pneumococcal meningoenzephalitis
Ciprofloxacin (Cipro, Bayer)	250 mg/animal PO once, then 125 mg q12h ⁵³ 16–20 mg/kg PO q12h ⁴³	Rhesus macaques/PD (5.1–13.0 kg animals) Based on PD dosage above ⁵³ ; suspension of crushed tablets in water
Clarithromycin	10 mg/kg PO q12h × 7 days ¹² 10 mg/kg PO q12h × 10 days ¹² 20 mg/kg PO q24h ¹	Rhesus macaques/treatment of <i>Helicobacter pylori</i> infection; part of quadruple therapy with omeprazole, amoxicillin, and bismuth subsalicylate ¹² Rhesus macaques/PD
Clindamycin	10 mg/kg PO q12h ¹⁰³ 12.5 mg/kg IM q8h ¹⁸	
Doxycycline	60 mg/animal PO once, then 30 mg q12h ⁵³ 3–4 mg/kg PO q12h ⁴³	Rhesus macaques/PD (5.1–13.0 kg animals) Based on PD dosage above ⁵³

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Enrofloxacin (Baytril, Bayer)	5 mg/kg PO, IM q24h × 10 days ^{2,19} 5 mg/kg nasogastric or orogastric intubation q24h × 10 days ⁶¹	<i>Shigella flexneri</i> ; injectable form given PO Macaques/PD ⁶¹ ; <i>Shigella</i> gastroenteritis	
Erythromycin	40 mg/kg PO, IM q8–12h ⁸ 75 mg/kg PO q12h × 10 days ⁴³	<i>Campylobacter</i> -associated diarrhea	
Erythromycin ethyl-succinate (pediatric suspension; EryPed Drops, Abbott)	20 mg/kg PO q12h ⁸⁸	Tamarins/clostridial enteritis	
Ethambutol	22.5 mg/kg PO q24h ¹¹²	Rhesus macaques/mycobacteriosis; treat concurrently with isoniazid and rifampin; reduce to 15 mg/kg after 6 wk; continue treatment for 1 yr; treatment of tuberculosis in nonhuman primates is controversial because of the inability to eliminate carrier state and potential of drug resistance ⁵⁰	496
Fluconazole (Diflucan, Roerig)	2–3 mg/kg PO q24h × 30 days ²⁹ 18 mg/kg PO q24h ³	Japanese macaques/coccidioidomycosis; prolonged treatment is necessary; relapses might occur after withdrawn from treatment Swamp monkeys/systemic mycoses; treat concurrently with flucytosine; may be effective as a sole agent	497
Flucytosine (Ancobon, Roche)	143 mg/kg PO q24h ³	Swamp monkeys/systemic mycoses; treat concurrently with fluconazole	
Furazolidone	5 mg/kg PO q6h × 7 days ⁴³ 10–15 mg/kg PO q24h ⁶⁹ 20–40 mg/kg PO q6h ⁴⁴		
Gentamicin	1–2 mg/kg IM, IV q8h × 5–7 days ⁴³ 2–3 mg/kg IM, IV q12h × 5–7 days ⁴³ 3 mg/kg IM q6–8h ¹⁰⁸	Baboons/PD	
Griseofulvin	20 mg/kg PO q24h ⁴⁴ 200 mg/kg PO once q10d ⁴⁴		
Imipenem	10 mg/kg IV ¹⁰⁰ 25 mg/kg IV q12h ²¹	Macaques, chimpanzees/PD Infuse over 30 min	
Isoniazid	15 mg/kg PO q24h ¹¹²	Rhesus macaques/mycobacteriosis; treat concurrently with ethambutol and rifampin; reduce to 10 mg/kg after 6 wk; continue treatment for 1 yr; supplement with pyridoxine; prophylactic use of isoniazid is controversial; treatment may mask infection and prevent detection by tuberculin skin testing; isoniazid has been associated with false-negative tuberculin skin testing results ⁵⁰	
Itraconazole	10 mg/kg PO q24h ⁴¹	Fungal (yeast) gastroenteritis	
Kanamycin	7.5 mg/kg IM q12h ⁴⁴		
Ketoconazole	5–10 mg/kg PO q12h ⁸	Candidiasis	
Lincomycin	5–10 mg/kg IM q12h ⁴³		
Methicillin sodium	50 mg/kg IM q12h × 7 days ³³		497

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Metronidazole	12.5–15.0 mg/kg PO q12h ⁴¹ 25 mg/kg PO q12h ⁷⁴ 50 mg/kg PO, or via orogastric tubing q24h ⁸	Clostridial infections Gastroenteritis Macaques/gastroenteritis; inflammatory bowel disease	498
Minocycline (Minocin, Lederle)	2 mg/kg PO q12h ⁴⁷ 15 mg/kg PO q12h × 7 days ^{43,49}	Prosimians ⁴⁷ Lemurs ⁴⁹	
Neomycin	10 mg/kg PO q12h ¹⁸		
Nitrofurantoin	2–4 mg/kg IM, IV q8h ⁴⁴		
Nitrofurazone	11 mg/kg PO q24h ³³		
Norfloxacin (Noroxin, Roberts)	25 mg/kg nasogastric intubation ²⁶ q12h 25–30 mg/kg PO q12h ⁸⁸	Rhesus macaques/PD Tamarins	
Nystatin	200,000 U/animal PO q6h ²³	Gastrointestinal candidiasis; continue 48 hr after clinical recovery	
Oxacillin	16.5 mg/kg SC, IM q8h ⁸		
Oxytetracycline	10 mg/kg SC, IM q24h ^{18,103}		
Penicillin G, benzathine	20,000–60,000 IU/kg SC, IM q24h ⁸ 40,000 IU/kg IM q72h ⁴⁴		
Penicillin G, procaine	20,000 IU/kg IM q12h ⁴⁴ 20,000–40,000 IU/kg SC, IM q12h ⁸ 50,000–60,000 IU/kg SC, IM q24h ⁷⁵	Macaques, squirrel monkeys	
Piperacillin sodium (Pipracil, Lederle)	80–100 mg/kg IM, IV q8h × 7–10 days ⁴³ 100–150 mg/kg IM, IV q12h ⁴³		
Rifampin	22.5 mg/kg PO q24h ¹¹²	Rhesus macaques/mycobacteriosis; treat concurrently with ethambutol and isoniazid; reduce to 15 mg/kg after 6 wk; continue treatment for 1 yr; controversial because of the public health danger and the induction of potential drug-resistant strains ⁵⁰	
Sulfamethazine	66 mg/kg PO q12h ⁷		498
Sulfasalazine (Azulfidine, Pharmacia & Upjohn)	20 mg/kg PO q24h × 28 days, then 40 mg/kg PO q24h ⁷⁶ prn 30 mg/kg PO q12h ⁴⁰ 50 mg/kg PO q24h × 10 wk ⁶⁶	Western lowland gorillas/reactive arthritis Cotton-top tamarins/chronic colitis	499
Tetracycline	20–25 mg/kg PO q8–12h × 7–10 days ⁴³ 25 mg/kg IM, IV q12h ⁴³		
Trimethoprim/sulfa	24 mg/kg PO q12h ²³ 25 mg/kg SC, IM q24h ¹⁶ 27 mg/kg SC q24h ²³ 50 mg/kg PO q12h ¹⁶	Lemurs Lemurs	
Trimethoprim sulfadiazine	15 mg/kg PO q12h ¹⁰³ 24–48 mg/kg SC ³³ 30 mg/kg SC q24h ¹⁰³		
Trimethoprim/sulfamethoxazole	15 mg/kg PO, IM q12h, or 30 mg/kg PO, IM q24h ⁴⁷ 50 mg/kg PO q24h ¹⁶	Prosimians Lemurs	
Tylosin (Tylen, Elanco)	5 mg/kg PO q12h ⁴¹ 10 mg/kg IM q12h ³³	Clostridial infections	

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Vancomycin	20 mg/kg IM, IV q12h ⁸ 40 mg/kg/day IV continuous infusion ²¹	499
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TABLE 69 Antiparasitic agents used in primates.

Agent	Dosage	Species/Comments
Albendazole	10 mg/kg PO ⁴⁷ 25 mg/kg PO q12h × 5 days ¹¹³ 28.5 mg/animal PO q12h × 10 days × 3 treatments with a 10 day interval ¹¹⁵	Prosimians/nematodes <i>Filaroides</i> Red ruffed lemurs/subcutaneous cysticercosis; also administer praziquantel 23 mg/animal PO q10d × 3 treatments
Amitraz	250 ppm dip for 2–5 min duration × 4 treatments q14d or until resolution of skin lesions ⁴²	Tamarins/demodectic mange; no haircoat clipping or bathing was performed; animals were not rinsed after treatment; dried with a hot-air dryer; ataxia (transient) developed for 72 hr after first treatment
Azithromycin	25–50 mg/kg SC q24h ⁸³ 40 mg/kg IM q24h first day; 20 mg/kg days 2–5 ⁸	Macaques/antimalarial Antibiotic
Chloroquine (Aralen, Sanofi)	10 mg/kg PO, IM once, then 5 mg/kg 6 hr later, then 5 mg/kg q24h × 2 days ¹¹³	Malaria (<i>Plasmodium</i> spp.); treat concurrently with primaquine
Dichlorvos	10–15 mg/kg PO q24h × 2–3 days ³⁵	Gastrointestinal nematodes
Diethylcarbamazine	6–20 mg/kg PO q24h × 6–15 days ^{102,113} 20–40 mg/kg PO q24h × 7–21 days ⁴³ 50 mg/kg PO q24 h × 10 days ¹³	Owl monkeys/filariasis (i.e., <i>Dipetalonema</i>) Squirrel monkeys/filariasis; effective against microfilaria and adults; monkeys were microfilaria negative for 12–24 wk after treatment
Doxycycline	5 mg/kg PO q12h once, then 2.5 mg/kg PO q24h ¹¹³	<i>Balantidium</i>
Fenbendazole	50 mg/kg PO q24h × 3 days ¹⁶ 50 mg/kg PO q24h × 14 days ¹¹³	Lemurs <i>Filaroides</i>
Furazolidone	— 5 mg/kg PO q6h × 7 days ¹⁰¹ 100 mg/animal PO q6h × 7 days ¹⁰¹	Great apes/ <i>Giardia</i> ; more palatable but less effective than other agents Great apes (juveniles) Great apes (adults)
Iodoquinol (diiodohydroxyquin) (Yodoxin, Glenwood)	— 12–16 mg/kg PO q8h ¹⁰¹ 20 mg/kg PO q12h × 21 days ⁴⁴ 30–40 mg/kg PO q24h × 3–21 days ⁶³	Great apes/minimal absorption; use with other agents for invasive disease; 14–21 days for <i>Balantidium coli</i> ; 21 days for <i>Entamoeba</i> Great apes (infants, juveniles) Intestinal amebiasis; <i>Balantidium</i> ; for treatment of cystic form, use in combination with metronidazole ⁸ Great apes
Ivermectin	0.2 mg/kg PO, SC, IM ^{16,43,113}	May repeat in 10–14 days
Levamisole	2.5 mg/kg PO q24h × 14 days ⁴⁶ 4–5 mg/kg PO q24h × 6 days ⁷³ 5 mg/kg PO, repeat in 21 days ³⁵ 7.5 mg/kg SC, repeat in 14 days 10 mg/kg PO ¹¹³	Prosimians/ <i>Physaloptera</i> Saki monkeys/oral spiruridiasis <i>Strongyloides</i> , <i>Filaroides</i> , <i>Trichuris</i>

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Mebendazole	15 mg/kg PO q24h × 3 days ¹¹³ 10–20 mg/kg PO q12h × 3 days, repeat in 14 days ⁴⁶ 22 mg/kg PO q24h × 3 days, repeat in 14 days ²³ 70 mg/kg PO q24h × 3 days ⁷³ 100 mg/kg PO q24h for alternating wk ⁷³	<i>Strongyloides</i> , <i>Necator</i> , <i>Pterygodermatitis</i> , <i>Trichuris</i> Prosimians/gastrointestinal nematodes New World primates/oral spiruridiasis; use treatment periodically Callitrichids/prevention of mortality by acanthocephalan; surgical excision of worms in the intestinal tract is recommended	
Mefloquine	25 mg/kg PO once ⁸	Antimalarial	
Metronidazole	17.5–25.0 mg/kg PO q12h × 10 days ¹¹³ 30–50 mg/kg PO q12h × 5–10 days ^{68,113}	Enteric flagellates and amoebas <i>Balantidium coli</i>	501
Neosarsphenamine	20 mg/kg IP q5d ⁷⁰	Squirrel monkeys/hemobartonellosis; arsenic compound dissolved and diluted in sterile distilled water (0.5 ml/dose)	502
Niclosamine	150 mg/kg once ¹⁰² 166 mg/kg ¹¹³	Owl monkeys/intestinal cestodiasis New World primates/cestodes, anoplocephalids	
Oxytetracycline	1500 mg/kg q24h IV, continuous infusion ¹⁰¹	Gorillas/ <i>Balantidium coli</i> ; nonambulatory animals	
Paromomycin (Humatin, Parke Davis)	10 mg/kg PO q8h × 5–10 days ¹⁰¹ 10–20 mg/kg PO q12h × 5–10 days ⁶⁸ 12.5–15.0 mg/kg PO q12h × 5–10 days ¹¹³ 25–30 mg/kg q12h × 5–10 days ¹⁰² 100 mg/kg q24h × 10 days ²⁸	Great apes/ <i>Entamoeba</i> <i>Balantidium coli</i> Amoebae; minimal absorption; use with other agents for invasive disease Owl monkeys/enteric amoebas Cercopithecids, pongids/antiprotozoan activity of the drug seems to be related to the protozoal species and the host species ²⁸	
Pentamidine isethionate (NebuPent, Fujisawa)	4 mg/kg IM, IV q24h × 14 days ¹⁰¹	Great apes/ <i>Pneumocystis</i> ; slow IV infusion; may cause hypotension, cardiac arrhythmias	
Piperazine	65 mg/kg PO q24h × 10 days ³⁵		
Praziquantel (Droncit, Bayer)	15–20 mg/kg PO, IM ¹¹³ 23 mg PO q10d × 3 treatments ¹¹⁵ 40 mg/kg PO, IM ¹¹³	Some cestodes Red ruffed lemurs/subcutaneous cysticercosis; administer with albendazole 28.5 mg PO q12h × 10 days × 3 treatments with a 10-day interval Trematodes	
Primaquine (Primaquine phosphate, Sanofi)	0.3 mg/kg PO q24h × 14 days ¹¹³	<i>Plasmodium</i> ; treat concurrently with chloroquine	
Pyrantel pamoate	5–10 mg/kg PO × 3 days ⁴⁷ 6 mg/kg PO ¹⁶ 11 mg/kg PO, once ¹¹³	Prosimians/nematodes Lemurs <i>Necator</i> ; pinworms	502
Pyrimethamine (Daraprim, Glaxo Wellcome)	2 mg/kg q24h × 3 days, then 1 mg/kg q24h × 28 days ^{101,113} 10 mg/kg q24h ⁸³	Great apes/ <i>Toxoplasma</i> ; maximum dosages of 100 mg/animal q24h for days 1–3 and 25 mg/animal q24h for 28 days; treat concurrently with sulfadiazine; supplement with folic acid <i>Plasmodium</i> ; folic acid antagonist; monitor for signs of folate acid deficiency	503
Quinacrine (Atabrine, Winthrop)	2 mg/kg PO q8h × 7 days ¹⁰¹	Great apes/ <i>Giardia</i> ; maximum dose of 300 mg/day	

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Ronnel (Ectoral, Mallinckrodt)	55 mg/kg PO q48h × 4 treatments, then q7d × 3mo ^{60,113} Topically ^{60,113}	Lung mites Ectoparasitic mites
Sulfadiazine	— 25–50 mg/kg PO q6h ¹⁰¹ 100 mg/kg/day PO ¹¹³	<i>Toxoplasma</i> ; treat concurrently with pyrimethamine Great apes/maximum dose of 6 g/animal/treatment
Sulfadimethoxine	50 mg/kg/day PO once, then 25 mg/kg/day ¹¹³	Coccidiosis
Tetracycline	15 mg/kg PO q8h × 10–14 days ¹⁰¹ 25–50 mg/kg PO q24h × 5–10 days ⁶³ 500–1000 mg/animal PO q8h × 10–14 days ¹⁰¹	Great apes (infants, juveniles)/ <i>Balantidium coli</i> Great apes/ <i>Entamoeba</i> , <i>Balanditium</i> Great apes (adults)/ <i>Balantidium coli</i>
Thiabendazole	50 mg/kg PO q24h × 2 days ¹¹³ 75–100 mg/kg PO, repeat in 21 days ³⁵	<i>Strongyloides</i> , <i>Necator</i>
Trimethoprim/sulfa	30 mg/kg PO q6h × 14 days ¹⁰¹	Great apes/ <i>Pneumocystis carinii</i>

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TABLE 70 Chemical restraint/anesthetic/analgesic agents used in primates.

Agent	Dosage	Species/Comments
Acepromazine	— 0.2 mg/kg IM ¹⁹ 0.5–1.0 mg/kg PO, SC, IM ⁴⁴	See ketamine for combination Moderate sedation; no immobilization Preanesthetic; tranquilizer
Acetaminophen (Children's Tylenol Grape Suspension, McNeil Consumer Products)	5–10 mg/kg PO q6h ⁴⁴	Analgesic; antipyretic; low antiinflammatory effects
Acetylsalicylic acid (aspirin)	— 5–10 mg/kg PO q4–6h ³⁴ 25 mg/kg rectal suppository ⁸² 100 mg/kg PO q24h ⁷	Analgesic; antiinflammatory; antipyretic Antiinflammatory; analgesic
Alphaxalone/alphadolone (Saffan, Glaxo)	— 5 mg/kg IV bolus ²² 10 mg/kg/h IV infusion ²² 10–12 mg/kg IV; continuous rate infusion of 0.2 mg/kg/min; or 4 mg/kg/20 min intermittent bolus ¹¹ 18 mg/kg IM ⁸¹	Injectable anesthetic; available in Europe Baboons/good surgical anesthesia lasting 5–10 min Marmosets/surgical anesthesia; rapid induction and recovery
Atipamezole (Antisedan, Pfizer)	— 0.15–0.30 mg/kg IV ⁶⁰ 0.2 mg/kg IV ⁸² 4 × medetomidine dose SC, IM, IV	Specific α_2 -adrenergic antagonist; medetomidine reversal Chimpanzees Squirrel monkeys
Atracurium	0.09–1.5 mg/kg ⁴	Macaques/nondepolarizing neuromuscular blockers; high dose produces histaminelike cardiovascular effects (sudden transient decrease in mean arterial pressure and increase in heart rate) and facial flushing ⁴
Atropine	— 0.02–0.05 mg/kg IM ⁸² 0.04 mg/kg SC, IM, IV ³⁵	Macaques, baboons/anticholinergic
Bupivacaine (0.25%)	1 mg/kg local infiltration ⁸²	Intercostal nerve block ⁸²
Bupivacaine hydrochloride (0.5%)	1.2 mg/kg epidural ²⁷	Rhesus macaques/epidural analgesia
Buprenorphine (Buprenex, Reckitt & Colman)	— 0.005–0.01 mg/kg IM, IV q6–12h ¹⁹ 0.01 mg/kg IM, IV q12h ³⁴ 0.01–0.02 mg/kg IM + flunixin meglumine 1 mg/kg SC, IM q6h ⁸² 0.01–0.03 mg/kg IM q6–12h ⁸⁹	Agonist-antagonist opioid ⁴⁰ ; analgesia ⁴⁰ Great apes

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Butorphanol (Torbugesic, Fort Dodge)	—	In primates, butorphanol displays a different pattern of receptor pharmacology; rather than being an antagonist at μ receptors, it behaves more as an agonist of intermediate efficacy; receptor binding studies have demonstrated that butorphanol has 12-fold μ to κ selectivity and 34-fold μ to δ selectivity ³⁶ ; may cause profound respiratory depression Tamarins
	0.01 mg/kg IV q3–4h ¹⁹	
	0.02 mg/kg SC ⁸²	
	0.025 mg/kg IM q3–4h ⁸⁹	
	0.1–0.2 mg/kg IM q12–48h ³⁴	
Carfentanil	0.3 μ g/kg IV ⁸²	Rhesus macaques/potent opioid; moderate sedation and analgesia; mild respiratory depression
Carprofen (Rimadyl, Pfizer)	2–4 mg/kg PO, SC q12–24h ⁸⁴	Nonsteroidal antiinflammatory; analgesia
Chlorpromazine	1–6 mg/kg PO, IM ⁴⁴	Preanesthetic
Detomidine (D)/(K) ketamine	—	Supplemental tiletamine-zolazepam was required for safe handling; complications: hypothermia, apnea, regurgitation, difficulty maintaining adequate anesthetic plane Mandrills, baboons
	(D) 0.44 mg/kg PO + (K) 10.2 mg/kg PO ⁷²	
	(D) 0.32 mg/kg PO + (K) 9.6 mg/kg PO ⁷²	Lowland gorillas
Diazepam	—	Used often as an adjuvant; see ketamine for combination Lemurs/prevents ketamine-induced seizures Seizures; muscle relaxation during anesthesia Sedation; give in small amount of food or drink 30–60 min before anesthesia; degree of sedation variable; recovery prolonged
Droperidol (D)/carfentanil citrate (C)	>20 kg (D) 2.5 mg PO + (C) 2 μ g/kg PO transmucosal ⁵²	Chimpanzees, bonobos/used to eliminate or minimize stress of darting; followed at 25 min by darting with a combination of tiletamine/zolazepam and naltrexone; droperidol was administered in grape juice, and transmucosal carfentanil was given directly onto oral mucous membrane by hand syringe; respiratory depression with low SpO ₂ ; provide supplemental oxygen; warning: use droperidol/carfentanil combination only as a premedication to tiletamine/zolazepam or ketamine anesthesia; the narcotic reversal agent must be given once animal reaches stage 4–5 anesthesia or at 25 min after dosing; naltrexone for reversal 100 \times carfentanil dose in mg
Enflurane	1 MAC = 1.84% ¹⁰⁴	Inhalant anesthetic
Etomidate	1 mg/kg IV induction; 100 μ g/kg/min IV continuous infusion maintenance ¹⁵	Decreases mean arterial pressure, heart rate, and myocardial contractility; increases systemic arterial compliance

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Fentanyl	0.13, 0.26, or 0.39 µg/kg/min IV continuous infusion ⁶⁷	Use with isoflurane MAC (1.53% ± 0.07%); fentanyl-sparing effect reduces isoflurane MAC by 19%, 44%, and 59%, respectively Orangutans (Sumatran)/immobilization; give in combination with vecuronium (1–3 mg/kg/h) and midazolam (0.05–0.1 mg/kg/h) continuous infusion Rhesus macaques/PO; use with isoflurane; side effects include bradycardia, hypotension Use with isoflurane anesthesia	507
	1–5 µg/kg/h IV continuous infusion ³⁰		
	5–10 µg/kg IV bolus ^{82,105}		
	10–25 µg/kg/h continuous infusion ⁸²		
Fentanyl/droperidol (Innovar-Vet, Janssen)	0.05–0.10 ml/kg IM, IV ⁴⁴	Preanesthetic; primates appear to be more sensitive to the drug than dogs ¹⁷ ; high doses produce respiratory depression Minor procedures	
	0.1–0.3 ml/kg SC, IM ⁸²		
Fentanyl/fluanisone (Hypnorm, Janssen)	0.3 ml/kg SC, IM ⁸²	Minor procedures	
Fentanyl transdermal patch (Duragesic, Janssen)	4–8 µg/kg/h, change patch q72h ^{59,85}	Analgesia; do not cut patch; cover portion not in use Rhesus macaques/8–10 kg; smaller patch adheres better to skin than larger (50 µg/kg/h); monitor closely for respiratory depression ⁵⁹	
	25 µg/kg/h × 2 patches		
Flumazenil (Romazicon, Hoffman-LaRoche)	0.025 mg/kg IV ³⁷	Benzodiazepine reversal	
Flunixin meglumine	0.3–1.0 mg/kg SC, IV q12–24h ³⁴	Nonsteroidal antiinflammatory; analgesia Prosimians Provide oral hydration therapy for the length of treatment to prevent gastrointestinal and renal side effects	
	0.5 mg/kg IM q24h ¹⁶		
	1–2 mg/kg SC, IM q6–12h ^{8,82}		
Glycopyrrolate	—	Anticholinergic Macaques, baboons	507
	0.005–0.01 mg/kg IM ⁸²		
	0.013–0.017 mg/kg IM ⁴³		
Halothane	1 MAC = 0.89%–1.15% ^{99,104} 0.5%–1.0% supplemented with 2:1 ratio of N ₂ O to oxygen (maintenance) ^{99,104}	Inhalant anesthetic; dose-dependent cardiovascular depression in macaques	508
Ibuprofen	20 mg/kg q24h PO ⁷⁸ 1% solution, subgingival irrigation ²⁴	Nonsteroidal antiinflammatory; analgesia Periodontitis	
Isoflurane	1 MAC = 1.28%–1.46% ^{98,104}	Inhalant anesthetic; no cardiovascular depression but profound respiratory depression; 55% MAC reduction when used with 2 mg/kg morphine IV ⁹⁸	

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Ketamine	—	Ketamine combinations follow; tranquilization; anesthesia; mg/kg dose increases as size of animal decreases; caution: causes seizures in lemurs when used as sole agent (see diazepam, midazolam, ketamine/acepromazine) Great apes/immobilization; follow with inhalant anesthetic; used in field immobilization of free-living mountain gorillas; ketamine provides a shorter recovery time than tiletamine/zolazepam ⁹⁶ All species Medium-size primates (10–30 kg)/immobilization; follow with inhalant anesthetic Marmosets, tamarins/immobilization; follow with inhalant anesthetic	
	5 mg/kg IM ³⁴		
	5–40 mg/kg IM ⁴³		
	10–15 mg/kg IM ³⁴		
	20 mg/kg IM ¹³		
Ketamine (K)/acepromazine (A)	(K) 4 mg/kg + (A) 0.04 mg/kg IM ¹⁶	Lemurs	
Ketamine (K)/diazepam (D)	(K) 15 mg/kg + (D) 1 mg/kg IM ¹⁸	Surgical anesthesia with good muscle relaxation lasting 30–40 min ¹⁹	
Ketamine (K)/medetomidine (M)	(K) 2–6 mg/kg IM + (M) 0.03–0.06 mg/kg IM ⁶⁰ (K) 3 mg/kg IM + (M) 0.04 mg/kg IM + butorphanol 0.4 mg/kg IM ¹¹⁰ (K) 5.0–7.5 mg/kg IM + (M) 0.033–0.075 mg/kg IM ⁹⁴ (K) 5–10 mg/kg IM + (M) 0.05–0.1 mg IM, IV ⁹	Chimpanzees Ring-tailed lemurs/anesthesia; long duration of action; rapid and complete reversibility with specific antagonists Use higher dosages for smaller primates	508
Ketamine (K)/midazolam (M)	<1 kg animal (K) 15 mg/kg IM + (M) 0.05–0.09 mg IV >1 kg animal (K) 15 mg/kg IM + (M) 0.05–0.15 mg IV ⁸²		509
Ketamine (K)/xylazine (X)	(K) 10 mg/kg + (X) 0.5 mg/kg IM ¹⁸	Surgical anesthesia with good muscle relaxation lasting 30–40 min; xylazine can be reversed with atipamezole ¹⁹	
Ketoprofen (Ketofen, Fort Dodge)	5 mg/kg IM q6–8h ⁸⁴	Nonsteroidal antiinflammatory; analgesia	
Ketorolac (Torador, Syntex)	15–30 mg/animal ⁸⁴ 15–30 mg/kg IM ²¹	Macaques, baboons/nonsteroidal antiinflammatory	
Medetomidine (Domitor, Pfizer)	— 0.04 mg/kg IM ¹¹⁰ 0.05–0.1 mg/kg PO ⁵¹ 0.05–0.1 mg/kg IV ⁹ 0.1 mg/kg SC, IM ⁸²	See ketamine for combinations Ring-tailed lemurs/combine with butorphanol (0.4 mg/kg IM) and midazolam (0.3 mg/kg IM) ¹¹⁰ Induction; followed by ketamine Inconsistent sedation; analgesia and muscular relaxation when used as a sole agent; side effects include bradycardia, hypotension, loss of thermoregulatory ability, and decreased mean arterial pressure; initial transient increase respiratory rate, followed by a longer-lasting decrease Squirrel monkeys/facilitates mask induction with isoflurane	

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Meperidine (Demerol, Winthrop-Breon)	2–4 mg/kg IM, IV q3–4h ^{34,89}	Analgesia; caution: sudden death reported in healthy animals ⁸⁹	509
Methohexitone	10 mg/kg IV ¹⁹	Surgical anesthesia, 50–10 min; reduce dose by at least 50% if ketamine is being used as a preanesthetic	
Midazolam (Versed, Roche)	0.05–0.1 mg/kg/h IV continuous infusion ³⁰ 0.1–0.5 mg/kg IM ³⁴ 0.2–0.4 mg/kg IV bolus ⁸²	Orangutans (Sumatran)/immobilization; given in combination with fentanyl (1–5 µg/kg/h) and vecuronium (1–3 mg/kg/h) continuous infusion Lemurs/prevents ketamine-induced seizures Balanced anesthetic technique with fentanyl (1–2 µg/kg IV bolus)	510
Morphine	— 0.125–1.0 mg/kg IV 1–2 mg/kg PO, SC, IM, IV q4h ⁸⁹	Opioid analgesia; dose-dependent respiratory depression; use with care, especially in New World primates; may cause intense pruritis around eyes and nose ³⁶ Squirrel monkeys ⁸²	
Morphine, preservative free	0.01 mg/kg ⁸² 0.1 mg/kg ⁸²	Intrathecal analgesia Epidural analgesia	
Nalbuphine	0.5 mg/kg IM, IV q3–6h ³⁴	Agonist-antagonist opioid	
Naloxone	0.01–0.05 mg/kg IM, IV ¹⁸	Opioid reversal	
Naproxen (Naprosyn, Syntex)	10 mg/kg PO q12h ^{43,49}	Lemurs/nonsteroidal antiinflammatory; analgesic; antipyretic ⁴⁹	
Neostigmine	0.1 mg/kg IV ³⁴	Anticholinesterase; antidote for nondepolarizing neuromuscular blocking agent; side effect: marked bradycardia; can be used with or without anticholinergic drugs	
Nitrous oxide (N ₂ O)	1 MAC = 200% ⁸² 25% N ₂ O reduced MAC halothane 0.76% (from 0.89%) ⁹⁹ 30% N ₂ O reduced MAC halothane 0.75% (from 1.15%) ¹⁰⁴ 30% N ₂ O reduced MAC enflurane 1.46% (from 1.84%) ¹⁰⁴	Macaques Minimal conservation of halothane in macaques; potentially delivering hypoxic gas mixture	
Oxymorphone	0.03–0.2 mg/kg SC, IM, IV q6–12h ³⁴ 0.075 mg/kg SC, IM, IV q4–6h ⁴⁰ 0.15 mg/kg SC, IM, IV q4–6h ⁴⁰	Analgesia New World primates Old World primates	
Pancuronium (Pavulon, Organon)	0.08–0.1 mg/kg IV ⁸²	Nondepolarizing neuromuscular blocker; requires assisted ventilation; use with caution	511
Pentazocine (Talwin-V, Upjohn)	2–5 mg/kg IM q4h ³⁴	Analgesia	
Pethidine	2–4 mg/kg IM q3–4h ¹⁸		
Pentobarbital sodium	20 mg/kg IV; decrease to 6.5–10.0 mg/kg if used with ketamine ⁸²	Severe respiratory depression; inability to modulate depth of anesthesia; prolonged recovery; considerable variation between species	

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Pentobarbitone	25–35 mg/kg IV ¹⁹	Light surgical anesthesia for 30–60 min; severe respiratory depression often occurs at higher doses; reduce dose by at least 50% if ketamine or other sedatives are being used	
Propofol	0.4–0.6 mg/kg/min IV continuous infusion ⁸² 1–2 mg/kg IV as initial bolus, followed by infusion to effect ⁸² 2 mg/kg IV (induction), 200 µg/kg/min IV continuous infusion (maintenance) ¹⁵ 2–4 mg/kg IV (induction) prn ⁸² 2.5–5.0 mg/kg IV bolus, followed by 0.3–0.4 mg/kg/min infusion ⁹¹ 5 mg/kg IV bolus, followed by 25 mg/kg/h infusion for maintenance ²²	Baboons, macaques Chimpanzees Decreases mean arterial pressure, heart rate, and myocardial contractility; increases systemic arterial compliance Baboons Macaques/after induction with ketamine; 20–40 min of anesthesia; intubation and ventilatory support suggested Rhesus macaques	
Sevoflurane	1 MAC = 2% ⁹⁷ 8% mask induction; 2.5% maintenance ⁹⁷	Garnett's greater bush baby/rapid induction and recovery; no significant cardiopulmonary effects; significant decrease in body temperature, WBC count, calcium, and total protein within 30 min of anesthesia ⁵⁷	511
Succinylcholine	2 mg/kg IV ³²	Depolarizing neuromuscular agent; requires assisted ventilation; use with caution	512
Thiamylal	25 mg/kg IV to effect ⁴⁴	Barbiturate anesthesia	
Thiopental	— 10–15 mg/kg IV bolus; 5–7 mg/kg IV if combined with ketamine ⁸² 15–17 mg/kg/h IV continuous infusion ⁸² 25 mg/kg IV to effect ⁴⁴	Barbiturate anesthesia Facilitates endotracheal intubation before induction with inhalants	
Thiopentone	15–20 mg/kg IV ¹⁹	Barbiturate anesthesia; surgical anesthesia, 5–10 min; reduce dose by at least 50% if ketamine used as premedication	
Tiletamine/zolazepam (Telazol, Fort Dodge)	1–20 mg/kg IM ⁹⁵ 1.5–3.0 mg/kg IM ⁶ 2–6 mg/kg IM ³⁹ 3–5 mg/kg IM ⁹⁵ 4–10 mg/kg IM ³⁴ 6 mg/kg IM ³⁴	Anesthesia; wide range of dosages for different species Macaques Great apes/gorillas can have severe ataxia during the recovery period, putting them at serious risk of injury ³⁶ Macaques/average duration of anesthesia 90 min; marked hypothermia ⁶⁴	
Tubocurarine	0.09 mg/kg IV ³²	Nondepolarizing neuromuscular blocking agent; requires assisted ventilation; use with caution	
Vecuronium (Norcuron, Organon)	0.04–0.06 mg/kg IV ⁸² 1–3 mg/kg/h continuous infusion ³⁰	Nondepolarizing neuromuscular blocking agent; requires assisted ventilation Orangutans (Sumatran)/immobilization; use in combination with fentanyl (1–5 µg/kg/h) and midazolam (0.05–0.1 mg/kg/h) continuous infusion	

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Xylazine	—	See ketamine for combination Light-to-moderate sedation; some analgesia
0.5 mg/kg IV ⁸²		

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TABLE 71 Miscellaneous agents used in primates.

Agent	Dosage	Species/Comments
Atropine	0.02–0.05 mg/kg SC, IM, IV ⁸²	Anticholinergic; reduces secretions; prevents bradycardia
Acetylcysteine (Mucomyst, Apothecon)	50–60 ml/h by inhalation × 30–60 min q12h ⁴⁴	Mucolytic
Aminophylline	10 mg/kg IV ¹⁶ 25–100 mg/animal PO q12h ⁴⁴	Lemurs/bronchodilation Bronchodilation
Bismuth subsalicylate (Pepto-Bismol, Procter & Gamble)	— 10 mg/kg PO q12h ¹² 17.5 mg/kg PO q6–8h ⁴³	Intestinal protectant; gastrointestinal ulcers
Calcium chloride	10–20 mg/kg IV (slow) ⁹⁰	Emergency treatment for hypocalcemia (monitor heart rate closely); cardiotonic; to reverse aminoglycoside-induced shock
Calcium gluconate	200 mg/kg SC, IM, IV ⁹⁰	Therapeutic agent for hypocalcemia and hyperkalemia; prophylaxis and therapy of nutritional secondary hyperparathyroidism
Captopril (Capoten, Squibb)	1 mg/kg PO ⁹⁰	Angiotensin-converting enzyme (ACE) inhibitor; vasodilator
Chlorpheniramine (Chlor-Trimeton, Squibb)	0.5 mg/kg/d PO, in divided doses ⁴⁴	Antihistamine; H ₁ receptor antagonist
Chlorpromazine	1–3 mg/kg IM ⁶⁹	Antiemetic
Cimetidine	10 mg/kg SC, IM q8h ⁵	H ₂ receptor antagonist; gastrointestinal ulceration
Cisapride (Propulsid, Janssen)	0.2 mg/kg PO q12h ³⁸	Macaques/promotes gastrointestinal motility; not commercially available in the United States
Dexamethasone	0.25–1.0 mg/kg PO, IM ⁶⁹ ≤2 mg/kg PO, IM, IV ⁴⁴	Antiinflammatory Antiinflammatory
Dimercaptosuccinic acid (DMSA) (Chemet, McNeil)	10 mg/kg PO q8h × 5 days, then q12h × 14 days ¹¹⁴	Chimpanzees/lead chelation
Diphenhydramine (Benadryl, Parke-Davis)	1 mg/kg IV ³⁰ 5 mg/kg IM ¹⁶	Lemurs/antihistamine
Diphenoxylate/atropine (Lomotil, Searle)	1 ml/animal PO q8h ³⁴	Opiate; antidiarrheal
Dobutamine	2–10 µg/kg/min IV continuous infusion ⁸²	Adrenergic β ₁ agonist; increases cardiac output
Dopamine	2–5 µg/kg/minute IV continuous infusion ⁸² 10 µg/kg/min IV continuous infusion ²¹	Low-to-moderate doses result in cardiac stimulation (positive inotropic effects) and renal and mesenteric vasodilation; augments cardiac contractility and increases urinary perfusion and output High doses result in increased peripheral resistance and renal vasoconstriction; bradycardia after cardiac arrest
Doxapram	2 mg/kg IV ¹⁸	Respiratory stimulant
Enalapril (Enacard, Merck)	0.015–0.125 mg/kg PO q12–24h ⁷¹ 0.3 mg/kg PO, IV ⁹⁰	Western lowland gorilla/antihypertensive Angiotensin-converting enzyme (ACE) inhibitor; balanced vasodilator

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Ephedrine	1.25–2.5 mg/kg IV ^{21,82} 12 mg/kg PO q4h ⁴⁴	Hypotension accompanied by bradycardia (macaques and baboons) Nasal congestion; bronchoconstriction	
Epinephrine	0.2–0.4 mg/kg diluted in 5 ml sterile water, IT ²¹ >3 kg or 1:10,000 dilution; 0.5–1.0 ml IV ²¹	Cardiac arrest	
Erythropoietin, recombinant	100 IU/kg IM ³⁰		
Famotidine (Pepcid, Merck)	0.5–0.8 mg/kg PO q24h ⁷⁴	Mild gastroenteritis; gastrointestinal ulcers	
Flavored drink, cherry (Koolaid, Kraft)	PO prn ²⁰	Mix with medication to enhance flavor; mix at 4× normal concentration	
Flavored drink, grape (Syrpalta, Emerson)	PO prn ⁷⁷	Mix as needed to flavor liquid medications and crushed tablets	
Flavored drink, orange (Tang, Kraft)		Add electrolyte salts to provide an oral hydration solution ^{8,20}	
Fluoxetine (Prozac, Eli Lilly)	0.45 mg/kg PO q24h ¹⁰⁶ 2 mg/kg PO or nasogastric intubation q24h ⁵⁸	Antianxiety Rhesus macaques (juveniles) ⁵⁸	514
Folic acid	0.04–0.2 mg/kg PO q24h ⁴³	Supplement during pyrimethamine therapy	515
Furosemide	1–2 mg/kg IV ^{21,102} 2 mg/kg PO ⁴⁴ 2–4 mg/kg PO q12–24h ¹⁰²	Diuresis; heart failure; pulmonary edema Loop diuretic Owl monkeys	
Glipizide (Glucotrol, Pfizer)	1.1 mg/kg PO q24h ²⁵	Titi monkeys/antihyperglycemic sulfonylurea; non-insulin-dependent diabetes mellitus	
Glycopyrrolate	0.005–0.01 mg/kg IM ⁸²	Anticholinergic	
Guanfacine	— 0.3 mg/kg PO, IM q12h × 5–10 days, followed by gradual reduction to 0.15 mg/kg q24h over 30 days ⁶⁵ 0.5 mg/kg PO, IM q12h × 5–10 days, followed by gradual reduction to 0.25 mg/kg q24h over 30 days ⁶⁵	Self-injurious behavior; decreases agitation without profound sedation Baboons Rhesus macaques	
Haloperidol (Haldol, McNeil)	0.03–0.05 mg/kg IM q12h ⁸ 0.5–2.0 mg/kg IM ⁹⁰	Macaques/self-injurious behavior Vervets, green monkeys/antianxiety	
Human chorionic gonadotropin (hCG)	250 U IM ⁹⁰	Squirrel monkeys/induces ovulation in 40% of the monkeys	
Insulin, NPH	0.25–0.5 U/kg/day SC starting dose ⁴³ 1.25 IU/animal q12h IM ¹⁰⁷	Diabetes mellitus; diabetic ketoacidosis Macaques/use combination of short-acting and longer-acting insulin (70:30) ¹⁰⁷ ; dose is highly variable (depending on individual, phase of disease, and concurrent medical conditions) and should be adjusted according to standard guidelines	
Isoproterenol	0.01–0.03 µg/kg/min IV ⁷⁹	Nonselective β-adrenergic agonist	
Kaolin/pectin	0.5–1.0 ml/kg PO q2–6h ⁴⁰	Intestinal protectant	515
Levothyroxine	0.01 mg/kg PO q12h ⁵⁶ 0.05 mg PO q24h ⁵⁵	Hypothyroidism Gorillas/hypothyroidism; after initial dosing, institute incremental changes of 0.025 mg q24h at 30-day intervals up to 0.1 mg q24h; monitor thyroid stimulating hormone (TSH) and T ₄ q6–8wk	516

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Lidocaine	0.02–0.05 mg/kg/min IV continuous infusion ⁸² 1–2 mg/kg IV ²¹	Ventricular arrhythmias; premature ventricular contractions
Mannitol (25%)	0.25–1.0 g/kg IV bolus over 20 min	Osmotic diuresis; reduces intracranial pressure
Metoclopramide	0.2–0.5 mg/kg IM q24h ⁸	Antiemetic; stimulates motility of upper gastrointestinal tract
Nitroprusside	1–4 µg/kg/min IV continuous infusion ⁸²	Vasodilator; antihypertensive
Norepinephrine	0.05–0.1 µg/kg/min IV continuous infusion ²¹	Hypotension
Omeprazole	0.4 mg/kg PO q12h ¹²	Rhesus macaques/gastric acid suppressant; proton pump inhibitor; use as part of quadruple therapy for <i>Helicobacter pylori</i> infection
Oxytocin	2 U/animal IM ⁸ 5–20 U/animal IM, IV ⁶⁹	Macaques/induction of late-term abortion (open cervix); repeat q2h maximum 3 treatments; monitor dam closely; provide analgesics; expulsion of retained placenta (within 12–24 hr); uterine inertia Uterine inertia
Paroxetine (Paxil, SmithKline Beecham)	0.3 mg/kg PO q12h ¹⁰⁶	Antianxiety
Phenobarbital	0.6 mg/kg PO q24h ⁴⁶	Prosimians/anticonvulsant
Phenylephrine	1–2 µg/kg IV bolus, followed by 0.5–1.0 µg/kg/min IV continuous infusion ^{21,82}	Hypotension
Phenylephrine (Neo-Synephrine, Winthrop)	Intranasal q6h ⁴¹	Nasal congestion
Prednisolone sodium succinate (Solu-Delta Cortef, Upjohn)	1–15 mg/kg IV ⁶⁹ 10 mg/kg IV ¹⁶	All species/shock Lemurs/shock
Prednisone	0.5–1.0 mg/kg PO q12h × 3–5 days, then q24h × 3–5 days, then q48h × 10 days, then ½ dose q48h ^{40,43}	Lower doses for pain, inflammation; higher doses for autoimmune, inflammatory bowel disease, etc.
Protamine	1 mg/80 U heparin IV ⁸² 4 mg/kg IV ³⁰	Administer slowly to avoid profound hypotension 1 mg protamine will neutralize 115 U porcine intestine or 90 U beef lung heparin; may cause hypotension, bradycardia, dyspnea, anaphylaxis; monitor activated partial thromboplastin time and activated clotting time
Pyridoxine hydrochloride	3.5 mg/kg in feed ³⁵	Supplement during isoniazid therapy
Ranitidine	0.5 mg/kg PO q12h ⁸	Antiulcerogenic; H ₂ receptor antagonist
Trimeprazine (Temaril P, Herbert)	1–2 mg/kg PO q6h ⁴⁴	Antihistamine
Tryptophan	100 mg PO q12h ¹⁰⁹	Macaques/self-injurious behavior; add to flavored commercial primate treat
Tolbutamine	250 mg q24h, then 100 mg q48h ^{31,107}	Capuchin monkeys/oral hypoglycemic agent; non-insulin-dependent diabetes mellitus
Vitamin C (ascorbic acid)	— 4–10 mg/kg PO q24h ⁴³ 25 mg/kg IM q12h × 5 days ⁸⁶ 30–100 mg/kg PO q24h ¹⁴	Vitamin C deficiency Rhesus macaques Macaques (young)

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Vitamin D ₃	250 IU/day PO ¹⁰³	Marmosets/daily requirement for animals housed in indoor exhibits without access to ultraviolet light	517
	5000 IU ergocalciferol depot (sesame oil) IM once at age 4 mo and ergocalciferol 400 IU PO q24h from age 4 mo until weaning ⁴⁸ 5000 IU ergocalciferol depot IM once and ergocalciferol 400 IU PO q24h until resolution of clinical and radiographic abnormalities ⁴⁸ 2000 IU/kg in feed q24h ⁴³	Chimpanzees (infants), orangutans (infants)/for prevention of rickets; monitor clinical signs, radiographic signs, and serum levels of 25(OH) vitamin D ₃ Chimpanzees (infants), orangutans (infants)/for treatment of rickets; monitor clinical signs, radiographic signs, and serum levels of 25(OH) vitamin D ₃	518
Vitamin E (E)/selenium (S)	(E) 3.75 IU/kg + (S) 1.15 mg/kg IM q3d × 30 days ⁹¹	(E)/(S) responsive myopathy, neuropathy	518

APPENDIX 92 Hematologic and serum biochemical values of primates.⁴³

Measurement	Baboon (<i>Papio</i> sp.)	Capuchin Monkey (<i>Cebus</i> sp.)	Chimpanzee (<i>Pan troglodytes</i>)	Common Marmoset (<i>Callithrix</i> sp.)	Lemur (<i>Lemur</i> sp.)
HEMATOLOGY					
PCV (%)	44.7	45–53	39.7–44.1	45–48	48–53
RBC (10 ⁶ /μl)	4.5–4.8	6	5.03–6.05	6.9	6.2–9.8
Hb (g/dl)	13	14–17	12.5–14.5	15.1–15.5	15.6–20.2
WBC (10 ³ /μl)	14.1	5–24	7.4–17.6	7–12	6.2–16.9
Neutrophils (%)	60.5	55	37.4–66.6	28–55	14–40
Lymphocytes (%)	36	41	29–57	43–67	49–81
Monocytes (%)	1.5	1.8	0–2.3	0.4–2.1	4
Eosinophils (%)	1.5	1.6	0–5.8	0.5–0.6	0–4
Basophils (%)	0.4	<1	0–0.7	0.3–1.3	<1
Platelets (10 ³ /μl)	406	108–187	216–482	390–490	—
CHEMISTRIES					
ALT (IU/L)	12–20	—	1.4–10.0	9.5–10.2	54.6
AST (IU/L)	22–28	—	4.0–13.4	160–182	20.3
Bilirubin (mg/dl)	0.3–0.4	—	0.06–0.28	0.5–0.6	—
BUN (mg/dl)	8–14	24–44	9–19	27	18.1
Calcium (mg/dl)	8–10	10	8–10	9.5–10.2	10.0–12.3
Cholesterol (mg/dl)	60–134	170–254	161–257	53–248	—
Glucose (mg/dl)	80–95	44–94	62–94	126–150	—
LDH (IU/L)	244–1100	—	—	799	180–210
Phosphorus (mg/dl)	5.5–8.5	7	3.6–6.0	1.6–10.4	4.3–7.6
Protein, total (g/dl)	6–7	7.5–8.7	6.7–8.1	7	7.8

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Measurement	Rhesus Macaque (<i>Macaca mulatta</i>)	Spider Monkey (<i>Ateles</i> sp.)	Squirrel Monkey (<i>Saimiri sciureus</i>)	Tamarin (<i>Saguinus</i> sp.)
HEMATOLOGY				
PCV (%)	39–43	35–40	43–56	45
RBC ($10^6/\mu\text{l}$)	4.5–6.0	5.5	7.1–10.9	6.6
Hb (g/dl)	12.7	16	12.9–17.0	15.5
WBC ($10^3/\mu\text{l}$)	11.5–12.4	10–12	5.1–10.9	12.6–14.4
Neutrophils (%)	20–56	52	36–66	43–64
Lymphocytes (%)	40–76	40	27–55	34–49
Monocytes (%)	0–2	3	0–6	2–5
Eosinophils (%)	1–3	5	0–11	1.0–1.2
Basophils (%)	0–1	0–1	<1	0.1
Platelets ($10^3/\mu\text{l}$)	130–144	239–343	112	331–650
CHEMISTRIES				
ALT (IU/L)	145–171	—	59–99	7–14
AST (IU/L)	20–34	—	56–118	49–59
Bilirubin (mg/dl)	0.10–0.66	—	0.10–0.53	0.14–0.26
BUN (mg/dl)	14.2–19.6	25.9	23–39	6–12
Calcium (mg/dl)	8.1–11.3	12.8	8.3–9.7	10
Cholesterol (mg/dl)	94–162	—	127–207	69
Glucose (mg/dl)	53–87	82.3	52–108	125–189
LDH (IU/L)	201–665	—	271–490	—
Phosphorus (mg/dl)	4–6	—	3.3–7.7	3–6
Protein, total (g/dl)	6.1–7.1	10.2	6.9–8.1	6.2–8.6

APPENDIX 93 Biologic and physiologic data of primates.⁴³

Species	Temperature °C (°F)	Respiratory (rate/min)	Heart Rate (beats/min)	Avg wt (kg) M/F	Estrus Length (days)	Gestation (days)	Weaning Age (days)	Life Span (max yr)
Baboon (<i>Papio</i> sp.)	36.0–39.0 (96.8–102.2)	29	80–200	21/12–15	31	175–180	180–456	40–45
Capuchin monkey (<i>Cebus</i> sp.)	37.0–38.5 (98.6–101.3)	30–50	165–225	3.8/2.7	16–20	160	270	46
Chimpanzee (<i>Pan troglodytes</i>)	35.5–37.8 (95.9–100.0)	35–60	80–150	42/31	36	228	547–1460	53
Common marmoset (<i>Callithrix</i> sp.)	35.4–39.7 (95.7–103.5)	20–50	240–350	0.31/0.29	16	148	60–180	12
Lemur (<i>Lemur</i> sp.)	37.9–38.1 (100.2–100.6)	—	168–210	2.9/2.5	39	135	105	27
Rhesus macaque (<i>Macaca mulatta</i>)	36.0–40.0 (96.8–104.0)	10–25	150–333	6.2/3.0	28	167	210–425	30
Spider monkey (<i>Ateles</i> sp.)	36.0–39.4 (96.8–102.9)	18–30	160–210	6.2/5.8	26	229	365	20
Squirrel monkey (<i>Saimiri sciureus</i>)	33.5–38.8 (92.3–101.8)	20–50	225–350	0.75/0.58	18	170	182	20
Tamarin (<i>Saguinus</i> sp.)	39.3–40.1 (102.7–104.2)	—	—	0.45/0.51	16	145	60–90	13

APPENDIX 94 Preventive medicine recommendations for primates. ^{43,45,62,79}

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Procedure	Schedule	Comments
Physical examination	Annually	Includes CBC, serum biochemical analysis, dental prophylaxis, etc.
Tuberculin testing (Intradermal Mammalian Tuberculin, Synbiotics; 800–247–1725)	0.1 ml ID 25–27 gauge needle; test annually	Tests are read at 24, 48, and 72 hr; a positive reaction is erythema and/or induration/edema persisting for >48 hr; tuberculin products with at least 1500 U per test dose are recommended (Mammalin Old Tuberculin – OT); intrapalpebral test site can be examined without restraint; alternate sites include the abdomen, thorax, antebrachium; newly arrived primates undergo a 90-day quarantine with tuberculosis test q14d × 3 treatments; surveillance of established primates includes testing Old World primates q3mo and New World primates q6mo if they are in contact with humans whose tuberculosis status is unknown; tuberculin testing of primates and staff in contact with primates should be performed annually in closed colonies; false-positives (especially in orangutans) and false-negatives (anergic animals) can occur; refer to recommendations in references if a positive reaction is obtained. ⁸⁷
Fecal parasite examination	q3–12mo	Direct wet mount of fresh feces for protozoa; flotation and/or sedimentation procedures for parasite ova; trichrome stains can be used to identify protozoal cysts
Fecal culture	Initial screen, then prn	Culture for <i>Salmonella</i> , <i>Shigella</i> , <i>Campylobacter</i> , <i>Yersinia</i> ; may take ≥3 samples to identify carriers of <i>Salmonella</i> or <i>Shigella</i> ; can be asymptomatic carriers; stain direct fecal smears to identify WBCs and RBCs if infectious enteritis is suspected
Serology	Initial screen and serum banking, then prn	Herpes B: all macaques; virus is shed intermittently and seronegative animals may still be latent carriers; all macaques should be handled as carriers regardless of serologic status because of fatal potential in humans Others (e.g., retroviruses, parainfluenza, measles, cytomegalovirus, hepatitis B); based on species and history (especially origin)
Tetanus vaccination	— 0.5 ml IM at 5–7 and 13–15 mo of age, then booster q5yr ⁷⁹ 3, 6, 9 mo of age, then booster q3–5yr, or in case of injury ⁴⁵ 2, 4, 6, 18 mo of age, then 4–6 yr and 14–16 yr of age, then booster q10yr ^{43,62} 40 IU human tetanus toxoid IM × 3 treatments at 2–3 mo interval; booster at 5 and 10 yr	All species/human tetanus toxoid can be used; give IM because SC deposition of aluminum adjuvants may cause sterile abscesses; the triple vaccine (diphtheria, tetanus, and pertussis) should not be used (a large number of adverse reactions have been reported) ¹⁰³ Based on human schedule

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Measles vaccination	—	Modified-live vaccine; do not vaccinate pregnant animals Monkeys Great apes, ⁴⁵ all species ^{43,62} /based on human schedule ^{43,62} Comparison of the efficacy of a canine distemper-measles and a standard measles vaccine for immunization of rhesus macaques showed that the canine distemper-measles vaccine was protective; animals vaccinated with 2-dose protocol canine distemper-measles developed higher neutralizing antibody titers than with standard vaccine ¹⁰	
	6 mo of age, then booster in 5–7 mo ⁴⁵ 15 mo of age, booster at 10–12 yr of age ^{43,45,62} 0.5 ml SC at >6 mo of age, booster at 13–15 ± mo of age ⁷⁹ 6 mo of age, then booster at 9 mo of age ¹⁰		
Poliovirus vaccination	—	Great apes only/modified-live oral vaccine; shedding of the vaccine virus may occur Based on human schedule; follow current human pediatric recommendations for route and frequency Great apes/juveniles Great apes/adults	
	2, 4, 18 mo of age, then 4–6 yr and 14–16 yr of age ^{43,62} 3, 6, 9, 24 mo of age ⁴⁵ q2mo × 3 vaccinations ⁴⁵ 2, 4, 15 mo of age, then 4–6 yr of age ⁷⁹		523
Rabies vaccination	—	Not sanctioned by the American Veterinary Medical Association; used by some institutions in rabies-endemic areas; use only killed virus preparations Capuchin monkeys/postexposure prophylaxis in monkeys that had direct contact with rabid bats; animals developed and maintained levels of rabies virus neutralizing antibody >0.05 IU/ml by 67 days after exposure ⁵⁴	524
	1 ml dose of killed vaccine IM (quadriceps muscle) days 2, 7, 12, 19, 33 postexposure and single dose of human rabies immunoglobulin IM 5 days postexposure		524

APPENDIX 95 Nonhuman primate laboratories.

Laboratory	Services
<p>BioReliance Corp. Simian Diagnostic Laboratory 14920 Broshart Road Rockville, MD 20850-3300, USA Telephone: 800-804-3586 301-610-2227 Fax: 301-610-2587 E-mail: info@bioreliance.com Website: www.bioreliance.com</p>	<p>Filovirus Screening; Macaque Antibody Panel (herpes B, measles, SIV, SRV, STLV-1); African Species Antibody Panel (measles, SA8, SA11, SIV, STLV-1); Retrovirus Antibody Panel (foamy virus, SIV, SRV, STLV-1)</p>
<p>California National Primate Research Center (CNPRC) Core Facilities University of California 1 Shields Ave. Davis, CA 95616-8542, USA Telephone: 530-752-0447 Website: www.primate.ucdavis.edu</p>	<p>Hormonal and immunologic assays, flow cytometry services</p>
<p>Esoterix Inc. Center for Infectious Diseases The Simian Diagnostic Laboratory Diagnostic Laboratory San Antonio, TX, USA Telephone: 210-836-2063</p>	<p>Panel A (macaques, Asian): B-virus, HSV-1, SIV, SRV, measles; Panel B (African species): SA8, HSV-1, SIV, CMV (SA6), measles; Panel C (New World species): Herpes tamarinus, measles, squirrel or cebus monkey CMV</p>
<p>Labcorp Center of Molecular Biology and Pathology 1447 York Court Burlington, NC 27215, USA Telephone: 800-533-0567 ext 3802 919-572-7544 Website: www.labcorp.com</p>	<p><i>Mycobacterium tuberculosis</i> detection by polymerase chain reaction (PCR) or other nucleic acid amplification methodology</p>
<p>National B Virus Resource Center Viral Immunology Center Georgia State University P.O. Box 4118 Atlanta, GA 30302-4118, USA Telephone: 404-651-0808 404-651-0812 Emergency: Dr. Julia Hilliard, Director: 404-358-8168 Fax: 404-651-0814; 404-651-0821 E-mail: bvirus@gsu.edu jhilliard@gsu.edu</p>	<p>Cercopithecine herpesvirus 1 (herpes B)</p>

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National Veterinary Services Laboratories <i>Mycobacterium</i> and <i>Brucella</i> Section Telephone: 515-663-7388 Pathobiology Section: 515-663-7200 Fax: 515-663-7315 Website: www.aphis.usda.gov/vs/nvsl	<i>Mycobacterium</i> testing and isolation	525
Simian Retrovirus Laboratory California National Primate Research Center (CNPLRC) University of California, Davis Davis, CA 95616, USA Telephone: 530-752-8242 Fax: 530-752-4816 Website: http://srl.primate.ucdavis.edu	Laboratory testing, consultation, and interpretation of the following viral agents: Simian Retrovirus Type D (SRV), Simian Immunodeficiency Virus (SIV), Simian T-Cell Lymphotropic Virus (STLV), Simian Foamy Virus (SFV)	526
11.1 APPENDIX 96 Literature cited—primates		527

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12 Wildlife

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12.1 APPENDIX 97 Checklist for the care of sick, injured, or orphaned wildlife.^a

Veterinarian's main responsibility is to provide the primary medical care; qualified personnel (rehabilitators) provide the aftercare and training for release.

Medical problems are frequently similar to those found in domestic animals; the wild animal's behavior and the restraint procedures required are different.

Rehabilitators can provide initial supportive care recommendations. Contact the International Wildlife Rehabilitation Council (707-864-1761; www.iwrc-online.org) or the National Wildlife Rehabilitators Association (320-259-4086; www.nwrawildlife.org) for rehabilitators near you.

Check with state and federal officials on local laws and permit requirements if you hospitalize wildlife.

Impact at the population level of releasing rehabilitated animals to the wild is minimal, and release may be important education opportunity for public; on occasion, a non-releasable animal can be placed in a conservation education or captive breeding program. Most importantly, wildlife presented for treatment are biomonitors of greater environmental problems.

When a patient is submitted, ask yourself the following questions:

1. What is medically wrong with the animal and can it be treated?
2. If treated, is the animal releasable or can it be placed in an education program? Unfortunately, euthanasia is often required.
3. If treatment is possible, can the animal survive the rehabilitation period (which may be months)?

Obtaining a history:

1. Is the "orphan" truly an orphan? If not, return to nest or site found (natural parents provide the best care). Rabbits and deer, in particular, leave their young unattended for much of the day. It is also important to know that the "scent of humans" will not cause rejection of the young by the mother. Although not common, some bird and mammals have been known to reclaim young even after several days. The public, therefore, should be encouraged to call you or a rehabilitator before they move the animal.
2. Advise the public not to approach rabies vector species if the animal is aggressive or displaying abnormal behavior.
3. If the rescuer has handled a rabies vector species, determine if potential exposure to rabies has occurred (bite or contact with saliva through broken skin or mucous membranes). If exposure has occurred, the local health department should be contacted.
4. When was animal found? Where? Get precise information.

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<p>5. What were the circumstances?</p> <p>6. Get name, address, and phone number of the rescuer.</p> <p>7. Has any medical or supportive care been provided?</p> <p>Initial patient evaluation (triage):</p> <ol style="list-style-type: none"> 1. Address life-threatening problems first. ABC: Check that the airway is clear; if the animal is not breathing, provide ventilation; check for a heart beat and pulse and provide cardiopulmonary resuscitation as necessary. 2. Uncontrolled bleeding is life threatening. Small animals, especially birds, have small quantities of blood. Total blood volume for most species is approximately 10% of body weight, and 10% loss of blood volume is considered an emergency. Broken blood feathers will need to be removed if actively bleeding. Apply direct pressure to the site of hemorrhage until it stops. Consider other forms of hemostasis, including cautery, ligation, and direct application of epinephrine to the area. 	535
<ol style="list-style-type: none"> 3. Assess the animal for shock. Common causes in wildlife include trauma, blood loss, and sepsis. Clinical signs include palpably cold extremities, pale and tacky mucous membranes, and a rapid heart rate. Treatment includes fluid therapy, steroids, and supplemental heat. 4. Once initial stabilization has been completed and life-threatening problems have been addressed, a more complete examination can be performed. However, only a cursory examination (to minimize stress) may be needed until an animal (especially an orphan) is hydrated and warm. Examination may have to be staged or delayed to avoid stress and potential mortality. 5. If possible, determine species and age. What is its natural history (herbivore/carnivore/frugivore/insectivore? Migratory, etc.)? 6. Determine if the animal is potentially carrying a zoonotic disease or other infectious agent. 7. Determine if special precautions or isolation is necessary. Knowledge of the appropriate methods of restraint and handling for the different species is essential. 8. Assume a minimum 10% dehydration for all sick or injured wildlife. 9. Administer hydrating solutions for the first 24-48 hours (parenteral: ½ strength LRS and 2½% dextrose, LRS, or Normosol [Abbott]; PO: Pedialyte [Ross], Gatorade [Gatorade], or Biolyte [Upjohn]. Continue to treat if there are ongoing fluid losses. 10. Treat hypothermia (provide an initial temperature range of ≈ 80° F–90° F [27° C–32° C]). Cover the animal with a blanket, and use hot water bottles to elevate the body temperature. If a heating pad is used, it should only be placed on the low setting. 11. Treat hyperthermia. Place the animal in a cool place and spray water on its feet and carefully in the mouth. Monitor body temperature closely to prevent rebound hyperthermia. 12. Determine the need for antibiotics. Most open wounds and animal bites will require antimicrobial therapy. 	536

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13. Determine the need for steroids. Spinal trauma and animals in shock may benefit from steroid therapy.
14. Determine the need for analgesics. Nonsteroidal antiinflammatory drugs are especially useful for head trauma, ocular trauma, other severe soft tissue damage and fractures.
15. Following the rewarming and rehydration phase, meet energy requirements (dextrose, Emeraid Carbo-Boost [Lafeber], etc.). To prevent refeeding syndrome, do not give food in the first 24 hours.
16. Determine the need for other medications and therapy.
17. Place in appropriate-sized incubator, cage, etc. provide proper substrate. Place the animal in a dark quiet area to minimize stress.

Problems of hand-rearing:

1. Runting, aspiration pneumonia, stress, malnutrition, enteropathies, and secondary diseases.
2. Behavioral problems (avoid taming or imprinting). In general, minimize exposure to humans and domestic animals. All birds should be raised with conspecifics and have a period of time outdoors for flight exercise before release.

General feeding guidelines for orphans:

1. Recommended diets are presented in the following appendixes.
2. Use only high-quality food products.
3. Stay consistent with formula diets.

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4. Neonatal animals may refuse to eat (e.g., management problems; inappropriate environmental temperature; inappropriate size, consistency, taste, or amount of diet).
5. Determine appropriate method of feeding (e.g., baby opossums must be fed via a stomach tube; not all baby birds gape).
6. Attempt to determine the amount of calories required for each day's feeding.
7. Neonatal mammals must be stimulated to urinate and defecate by gently brushing anal and genital areas with moist cotton or clean tissue after each feeding.

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Release criteria:

1. Animals must meet the following criteria in order to be released to the wild:
 - The animal has recovered from its initial problem and it will not recur.
 - The animal is able to avoid predators.
 - The animal is able to find food in the wild.
 - The animal has been cured of any secondary problems.

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- The animal must be expected to function reasonably within the population.
 - The animal does not pose a risk to the wild population or the environment, nor is it likely to spread pathogens or contribute to disease processes in other ways.
 - The animal is not carrying a potentially zoonotic infection.
2. Animals must be released at the original site of capture unless conservation efforts or safety considerations dictate otherwise. Animals should be released in their natural environment and habitat suitable for species survival, but in areas away from traffic, people, and pets. The habitat must be within carrying capacity for the species. Check local and state laws regarding release of deer and rabies vector species.
 3. Animals that cannot be returned to the wild for any reason should be euthanatized unless they can be placed in educational, research, or breeding programs.

^a See references in following appendixes.

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APPENDIX 98 Recommended diets and weaning considerations for orphaned wild mammals.^{a-k}

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Species	Diet	Frequency	Weaning
Armadillo	Esbilac (Pet-Ag) or Zoologic 33/40 (Pet-Ag) and water 2:3	2–4× daily	Wean at 6–8 wk onto cat/dog or kitten/puppy chow or canned food and native food. Adding grubs, insects, and insect eggs to their diet will gradually adapt them to natural food. Supplemental vitamin K ₁ is required. They enjoy swimming in dishpans. To reintroduce into the wild, take them outside to forage for insects.
Badger	Esbilac or Zoologic 33/40 and water 4:7	2–3× daily	Wean at 8–10 wk onto canned and dry dog or cat food and native food. Release at 5 mo.
Bat	Bat milk: • Zoologic 33/40 and water 1:2–3 • 1 drop Avitron (Lamber K) and 2 drops Avimin (Lamber K) to every 35 ml of formula	Feed via 1–3 ml syringe 3–4× daily	Insectivorous bats: add mealworms and crickets until ready to be housed with adults and/or trained for release. Feed in a head-down and sternal position. Frugivorous bats: add pureed bananas, grapes, melon, papaya, and apples. Wean at 3–4 wk.
Beaver	Esbilac and Multi-Milk (Pet-Ag) 2:1 or Esbilac and Zoologic 30/55 (Pet-Ag) and water 2:2:3	3–4× daily	Wean at 8 wk onto rodent pellets and native food (shrubs, twigs, branches, dark leafy greens, etc.).
Bobcat	KMR (Pet-Ag) or Zoologic 42/25 (Pet-Ag) and water 2:3	3–4× daily	Wean at 8–9 wk onto rodents. May begin nibbling on chopped skinned rats or pureed rodents (or cat food) at 10 days of age. Gradually add soaked dry Mazuri Feline diet and live rodents. Release at 4–5 mo in a similar manner to the fox and coyote.
Coyote	Esbilac or Zoologic 33/40 and water 4:5	2–4× daily	Wean at 5–7 wk onto puppy canned or dry food and rodents (e.g., chopped skinned rats or pureed mice) with 5% fruit and 5% vegetables. May begin nibbling on pureed rodents (or dog food) at 10 days of age. Gradually introduce live rodents for them to kill. A litter can be released at 5–6 mo. Very difficult to rear and release single animals.
Deer (white-tailed)	Lamb, kid (goat), or doe (deer) milk replacer	2–4× daily (generally 1 oz/lb 2 × daily) with a lamb's nipple. Can use goat or cow colostrum if the neonate hasn't nursed.	Gradually decrease the number of feedings by 1/day over a period of ≈ 1 wk as the fawn starts nibbling grass. Wean at 8–12 wk on a wild ruminant diet (16%–25% protein), hay, and variety of browse (never use wild cherry and avoid too much maple and oak). Be careful handling fawns; they panic easily and may injure themselves in escape attempts. Best to raise with conspecifics (do not raise alone). Very easily tamed; limit number of people in contact.
Fox (red or gray)	Esbilac or Zoologic 33/40 and water 4:7	2–3× daily	Wean at 7–8 wk onto puppy canned and dry food, rodents (e.g., pureed mice) with 5% fruit and 5% vegetables. May begin nibbling on pureed rodents (or soaked puppy chow) at 10 days of age. Gradually introduce live rodents for them to kill. A litter can be released at 5–6 mo. Very difficult to rear and release single animals.

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Opossum	Esbilac and Multi-Milk 4:1 or Esbilac and Zoologic 30/55 and water 2:1:4 (add pinch of calcium/phosphorus powder to formula)	3–6× daily (must tube feed max 1.5 ml/28 g BW)	Wean at 13–15 wk onto canned and dry dog or cat food and native food. Supplemental calcium is required as well as 10% vegetables, 5% fruit, and chopped mice. House carefully (they will get out, crawl behind things, and not come out even to eat). Do not overcrowd as cannibalism may occur. Feed in a sitting position with forefeet elevated. Release at 500–700 g.	539
Rabbit	Esbilac and Multi-Milk 3:2 or Zoologic 30/55 and Zoologic 42/25 and water 3:2:5	2–4× daily	Begin weaning at 2–3 wk by gradually adding native forage, hay grass clippings, rabbit pellets, apples, carrots, and oats. Avoid overhandling (shock). Acidophilus (e.g., yogurt) may be a useful supplement; small amount of honey may promote eating if they initially reject the milk. Place them in wire mesh bottom cages outside; release at 3–5 wk (when eating a natural diet).	540
Raccoon	KMR or Zoologic 42/25 and water 1:2	3–5× daily (need to be burped)	Wear latex gloves due to risk for <i>Baylisascaris procyonis</i> . Wean at 8–10 wk onto dry puppy food and native food. Add 10% vegetables and 5% fruit. They become aggressive with age. Feed in sitting position with forefeet elevated. Never raise alone and release at 16 wk.	
Skunk	Esbilac or Zoologic 33/40 and water 4:5	2–4× daily depending on the age	Wear latex gloves due to risk for <i>Baylisascaris columnaris</i> . Wean at 6–8 wk onto dry puppy food, rodent pellets, and native food. Add 10% vegetables and 5% fruit. Release at about 12–14 wk.	
Squirrel	3 oz Esbilac or Unilac (Foremost McKesson) 1 tsp baby cereal (eyes open only)	At least q2h (feed with animal on belly)	Wean by 6 wk onto rodent pellets, vegetables, crackers, fruit, and a variety of nuts and grain. Adapt easily to the wild once weaned. Release at 12–14 (occasionally 10) wk.	540
Woodchuck (groundhog) and marmot	Esbilac or Zoologic 33/40 and water 4:5	2–4× daily	Wean at 6–8 wk onto rodent or rabbit pellets (if long-term captivity is anticipated) and native forage (vegetables, grains, fruit, seed, and nuts). They enjoy playing in sand. Release at 14–16 wk.	541

- a Although this outline is intended to provide general guidelines for the care of orphaned wildlife, the veterinarian is strongly encouraged to transfer these animals to experienced rehabilitators as soon as possible and/or to contact rehabilitators if questions arise. In addition, any individual working with wildlife should check with state and federal officials on permit requirements.
- b Avoid overfeeding of orphaned wild mammals.
- c _____. Zoologic milk matrix formulation and mixing guide. Pet-Ag, Hampshire, IL.
- d Derrell Clark J, Olfert ED. Rodents. In: Fowler ME (ed). *Zoo & Wild Animal Medicine*. WB Saunders, Philadelphia, 1986. pp. 728–747.
- e Evans RH. Care and feeding of orphan mammals and bird. In: Kirk RB (ed). *Current Veterinary Therapy IX: Small Animal Practice*. WB Saunders Co, Philadelphia, 1986. pp. 775–787.
- f Fairbrother LN, Locke LN, Hoff GL (eds). *Noninfectious Diseases of Wildlife*. ed. 2. Iowa State University, Ames, IA, 1996.
- g Gage, LJ. *Hand-Rearing Wild and Domestic Mammals*. Iowa State, Ames, IA, 2002.
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- i Lollar A, Schmidt-French B. *Captive Care and Medical Reference for the Rehabilitation of Insectivorous Bats*. Bat World, Mineral Wells, TX, 1998.

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- j Marcum D. *Rehabilitation of North American Wild Mammals: Feeding and Nutrition*. International Wildlife Rehabilitation Council, Suisun, CA, 1997.
- k Moore AT, Joosten S. *Principles of Wildlife Rehabilitation*. National Wildlife Rehabilitation Association, St Cloud, MN, 1997.

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APPENDIX 99 Feeding frequency and temperature recommendations for hand-rearing orphaned, altricial birds.^{a-c}

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Age Class	Characteristics	Feeding Frequency	Temperature ^d
Hatchling (days 0 to 4)	No feathers or small amount of down; bulbous body; frail appendages; unable to sit up; eyes closed	q15min (7 AM-9 PM)	80° F–90° F (26° C–32° C)
Nestling (days 4 to 10)	Quills show; feathers sprout; downy feathers on head; cannot perch; eyes open	q20–30min (7 AM-9 PM)	80° F–85° F (26° C–29° C)
Fledgling (days 10 to 14)	Feathered; short tail feathers; first attempts to fly; can perch; will preen	q40–60min (7 AM-9 PM)	70° F–80° F (21° C–26° C)
Juveniles/immatures (>15 days to adult)	Feathered; defensive; able to fly; still being fed by parents	q2–4h Provide items for self-feeding (7 AM-9 PM until self-feeding)	70° F–80° F (21° C–26° C)
Adults	Adult plumage; aggressive; normally arrive injured	Self-feeding or force-feeding	70° F–80° F (21° C–26° C)

- a Although this outline is intended to provide general guidelines for the care of orphaned wildlife, the veterinarian is strongly encouraged to transfer these animals to experienced rehabilitators as soon as possible and/or to contact rehabilitators if questions arise. In addition, any individual working with wildlife should check with state and federal officials on permit requirements.
- b Evans RH. Care and feeding of orphan mammals and bird. In: Kirk RB (ed). *Current Veterinary Therapy IX: Small Animal Practice*. WB Saunders Co, Philadelphia, 1986. pp. 775–787.
- c Moore AT, Joosten S. *Principles of Wildlife Rehabilitation*. National Wildlife Rehabilitation Association, St Cloud, MN, 1997.
- d After the bird is healthy and normothermic.

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APPENDIX 100 Suggested diets used in hand-rearing orphaned, altricial wild birds.^{a-f}

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Species	Diet ^b	Diet ^{c,g}	Diet ^d
Ground insectivores (e.g., robins, thrushes, towhees, wrens)	1 cup Hill's Science Diet p/d dog food (or Purina Hi-Pro dog food) softened in water ½ cup mynah bird food/turkey pellets 2 soft-boiled eggs; berries ½ cup cooked Roman Meal cereal 1 tsp dark loam, 1 tsp dolomite vit/min mix Mix above diet 1:1 with earthworms	1 part Hill's Science Diet Feline Growth 1 part Gerber's High Protein Cereal 1 tsp bone meal Water for proper consistency Add: crickets, mealworms, earthworms, grubs, grasshoppers, and some berries	See below ^h
Aerial insectivores (e.g., swallows, kingbirds, phoebes, swifts, nighthawks) ⁱ	1 cup high-protein pabulum; 1 soft-boiled egg ¼ cup cooked Roman Meal cereal 1 cup dried insect mix (fish food) Mix above diet 1:1 with live insects; feed in small bites	1 part Hill's Science Diet Feline Growth 2 parts Gerber's High Protein Cereal Ca supplement; water for proper consistency Supplement with crickets, mealworms, grubs, waxworms, grasshoppers	—
Insectivorous omnivores (e.g., blackbirds, mockingbirds, orioles, thrashers, warblers, tanagers)	Same as for ground insectivores, except cooked Roman Meal cereal is increased to ½ cup and insects or worms can be used	1 cup ZuPreem Dry Omnivore Chow ½ cup Gerber's High Protein Cereal 3 Tbs brewer's yeast <i>Lactobacillus</i> spp., <i>Streptococcus faecium</i> ^k Vitamin/bone meal; water for consistency Supplement with fresh, thawed crickets	See below ^j
Insectivorous frugivores (e.g., waxwings, flickers, wood-peckers)	Same as for insectivorous omnivores, but 20% of diet is berries	—	—
Omnivores (e.g., jays, shrikes, crows, grackles)	Same as for insectivorous omnivores, but chopped, skinned mice and insects can be added (not more than 10% of diet)	1 part Hill's Science Diet Feline Growth 1 part Gerber's High Protein Cereal (or ZuPreem Dry Omnivore Chow, soaked) <i>Lactobacillus</i> spp., <i>Streptococcus faecium</i> ^f vitamin/bone meal; water for consistency add: crickets, grubs, flies, small pieces of fruit or Gerber's strained fruit	See below ^h

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Granivores (e.g., finches, chickadees, juncos)	Same as for insectivorous omnivores; at day 10, 20% of diet is seed	¼ cup Hill's Science Diet Feline Growth ½ cup Gerber's High Protein Cereal 2 Tbs Gerber's strained peas (or Heinz dehydrated peas/carrots) <i>Lactobacillus</i> spp., <i>Streptococcus faecium</i> ^k vitamin/bone meal; water for consistency	See below ^j
Columbiformes (e.g., pigeons, doves)	Exact (Kaytee), Nutristart (Lafeber), or other commercial psittacine hand-rearing diet; must tube feed 2–4 × daily until crop is 3/4 full	—	—

- a Although this outline is intended to provide general guidelines for the care of orphaned wildlife, the veterinarian is strongly encouraged to transfer these animals to experienced rehabilitators as soon as possible and/or to contact rehabilitators if questions arise. In addition, any individual working with wildlife should check with state and federal officials on permit requirements.
- b Evans RH. Care and feeding of orphan mammals and bird. In: Kirk RB (ed). *Current Veterinary Therapy IX: Small Animal Practice*. WB Saunders, Philadelphia, 1986. pp. 775–787.
- c Project Wildlife, San Diego, CA.
- d Carpenter JW, Rupiper DJ. Personal communication. 2004.
- e Baicich PJ, Harrison C. *A Guide to the Nests, Eggs, and Nestlings of North American Bird*. ed. 2. Academic Press Natural World, San Diego, 1997.
- f Ehrlich PR, Dobkin D, Wheye D. *The Birder's Handbook*. Simon and Schuster/Fireside, New York, 1988.
- g Hatchlings of all species can be fed diet consisting of 1 part hard-boiled egg yolk, 1 part Gerber's High Protein Cereal, 1 part soaked Feline Growth, mixed with warm water.
- h Use a combination of a commercially prepared psittacine hand-rearing formula and Science Diet p/d (Hill's).
- i These birds are very difficult to raise and generally require the skills of experienced rehabilitators.
- j Use a commercially prepared psittacine hand-rearing formula (i.e., Exact [Kaytee], Nutristart [Lafeber]).
- k Bird Bene-Bac Gel, Pet-Ag.

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APPENDIX 101 Suggested diets used in hand-rearing precocial, semiprecocial, and semialtricial orphaned wild birds.^{a-c}

Species	Diet
Galliformes (e.g., pheasants, quail, grouse, turkeys)	Commercial game-bird, turkey, or chicken starter and growing ration (use small size ration for quail); supplement with insects, berries, and natural food such as acorns; small amount of grit
Anseriformes (e.g., ducks, geese)	Duck starter pellets (wk 1–4) and duck grower/finisher pellets (until mature); alternatively can use commercial “all purpose pellets”; supplement with fresh aquatic vegetables; access to grit. A “wet” meal can be provided by using starter pellets in water bowl with finely chopped dark leafy greens on top
Gruiformes (e.g., coots, gallinules, rails, cranes)	Commercial poultry, gamebird, waterfowl, or crane diets; can be supplemented with insects (e.g., mealworms), minced rodents, and aquatic vegetables
Charadriiformes (e.g., gulls, terns, plovers, sandpipers)	Mixture of soaked dry dog food (ground or minced rodents if available), insects, and fish
Ciconiiformes (e.g., herons, egrets, bitterns)	Minced or ground, whole rodents (skinned) for the first 10–14 days, then chopped rodents can be fed; or fresh or recently air-thawed fish at a rate of 30%–60% of body weight daily; may need to supplement with vitamins (e.g., E, B ₁)
Falconiformes (hawks) and Strigiformes (owls) ^d	Ground or minced, skinned, and beheaded adult rodents or plucked day-old chicks or quail rolled in bone meal (for falcons) for the first 2–10 days; thereafter, chopped whole animals (with some fur/feathers) can be fed until the bird is forming pellet well; then allow free access to food

- a Although this outline is intended to provide general guidelines for the care of orphaned wildlife, the veterinarian is strongly encouraged to transfer these animals to experienced rehabilitators as soon as possible and/or to contact rehabilitators if questions arise. In addition, any individual working with wildlife should check with state and federal officials on permit requirements.
- b Evans RH. Care and feeding of orphan mammals and bird. In: Kirk RB (ed). *Current Veterinary Therapy IX: Small Animal Practice*. WB Saunders, Philadelphia, 1986. pp. 775–787.
- c Carpenter JW, Rupiper DJ. Personal communication. 2004.
- d Imprinting is especially common in these species.

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¹³Selected Appendixes

James W. Carpenter, MS, DVM, Diplomate ACZM

APPENDIX 102 Classification of select antibacterials used in exotic animal medicine.

Type	Antibacterial Agent
Benzyl penicillins ^a	Benzathine penicillin G
	Procaine penicillin G
Extended-spectrum penicillins ^a	
Aminopenicillins	Amoxicillin
Antipseudomonal penicillins	Ampicillin
	Carbenicillin
Carboxypenicillins	Ticarcillin
Piperazine penicillins	Piperacillin
Carbapenems	Imipenem
β-Lactamase inhibitors	
Clavulanic acid	Amoxicillin-clavulanate
	Ticarcillin-clavulanate
First-generation cephalosporins ^a	Cefadroxil
	Cefazolin
	Cephalexin
	Cephalothin
	Cephradine
Third-generation cephalosporins ^a	Cefixime
	Cefotaxime
	Ceftazidime
	Ceftiofur
Fourth-generation cephalosporins ^a	Cefepime
	Cefpirome
Macrolides ^b	Clarithromycin
	Erythromycin
	Tilimicosin
	Tylosin
Azalide	Azithromycin
Ketolide	Telithromycin
Tetracyclines ^b	Chlortetracycline
	Doxycycline
	Oxytetracycline
	Tetracycline
Chloramphenicol (or its derivative) ^b	Chloramphenicol
	Florfenicol

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Lincosamides ^c	Clindamycin	547
	Lincomycin	
	Pirlimycin	
Aminoglycosides ^a	Amikacin	548
	Gentamicin	
	Kanamycin	
	Neomycin	
	Streptomycin	
	Tobramycin	
Aminocyclitols	Spectinomycin ^b	547
Nitroimidazole	Metronidazole ^d	548
Sulfonamides ^b	Sulfachlorpyrdazine	548
	Sulfadiazine	
	Sulfamethoxazole	
	Sulfadimethoxine	
	Sulfamethazine	
	Sulfaquinoxaline	
	Sulfathiazole	
	Sulfisoxazole	
Trimethoprim ^b	Trimethoprim	548
Trimethoprim-sulfa ^a	Trimethoprim-sulfadiazine	
	Trimethoprim-sulfamethoxazole	
Quinolones	Nalidixic acid	548
Fluoroquinolones ^a	Ciprofloxacin	
	Danofloxacin	
	Difloxacin	
	Enrofloxacin	
	Marbofloxacin	
	Orbifloxacin	

a Bacteriocidal.

b Bacteriostatic.

c Bacteriostatic or bacteriocidal.

d Cidal vs. amoebae, *Giardia*, *Trichomonas*, and most obligate anaerobes; inactive vs. most aerobic bacteria or facultative anaerobes.

APPENDIX 103 General efficacy of select antimicrobial agents used in exotic animals.

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Gram-positive bacteria	Gram-positive bacteria (in general)
	Azalides
	Lincosamides
	Cephalosporins
	Tetracyclines
	Penicillins
	Macrolides
	Select aminoglycosides (gentamicin, kanamycin)
	Chloramphenicol
	Florfenicol
	Fluoroquinolones
	Erythromycin

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Staphylococcus spp.

Early-generation penicillins

Early-generation cephalosporins

Early-generation β -lactams

Macrolides

Azithromycin

Select aminoglycosides (gentamicin, kanamycin)

Lincosamides

Fluoroquinolones

Chloramphenicol

Trimethoprim-sulfa

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Streptococcus spp.

Cephalosporins

Penicillins

Early-generation β -lactams

Select aminoglycosides (gentamicin)

Macrolides

Azithromycin

Lincosamides

Tetracyclines

Chloramphenicol

Fluoroquinolones

Trimethoprim-sulfa

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	<p><i>Clostridium</i> spp. and other anaerobes</p> <p>Penicillins (amoxicillin-clavulanate)</p> <p>Cephalosporins (not first generation)</p> <p>Metronidazole^a</p> <p>Clindamycin</p> <p>Azithromycin</p> <p>Lincomycin</p> <p>Tetracyclines</p> <p>Erythromycin</p> <p>Chloramphenicol</p> <p>Florfenicol</p>	549
Gram-negative bacteria	Enterobacteriaceae (in general)	550
	<p>Advanced-generation penicillins</p> <p>Advanced-generation cephalosporins</p> <p>Advanced-generation β-lactams</p> <p>Azalides</p> <p>Fluoroquinolones</p> <p>Trimethoprim-sulfa</p> <p>Aminoglycosides (amikacin)</p>	

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Campylobacter sp.

Erythromycin

Doxycycline

Chloramphenicol

Furazolidone

Gentamicin

Neomycin

Clindamycin

Pasteurella spp.

Sulfonamides

Penicillins

Erythromycin

Amikacin

Kanamycin

Fluoroquinolones

Trimethoprim-sulfa

Tetracyclines

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<i>Pseudomonas</i> sp. (often resistant)	
Aminoglycosides (frequently in combination with an advanced-generation β -lactam)	
Advanced-generation β -lactam	
Fluoroquinolones	
Advanced-generation penicillins (carbenicillin, ticarcillin; frequently in combination with an aminoglycoside)	
Advanced-generation cephalosporins (frequently in combination with an aminoglycoside)	
Chloramphenicol	
<i>Salmonella</i> spp.	
Fluoroquinolones	
Chloramphenicol	
Advanced-generation penicillins	
Trimethoprim-sulfa	
Tetracyclines	
Aminoglycosides	
<i>Chlamydia</i>	
Tetracyclines (doxycycline)	
Enrofloxacin (vs. some species)	
Azithromycin	
Erythromycin	

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Mycoplasma

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Tetracyclines

Macrolides

Azithromycin

Enrofloxacin

Lincosamides

Chloramphenicol

a Effective vs. most obligate anaerobes; inactive vs. most aerobic bacteria or facultative anaerobes.

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APPENDIX 104 Antimicrobial therapy used in exotic animals according to site of infection.^{a,b}

Site of Infection	Antimicrobial Agent
Bacteremia, septicemia	
Aerobic bacteria	<p>Aminoglycoside with a penicillin or cephalosporin</p> <p>Enrofloxacin with amoxicillin</p>
Anaerobic bacteria	<p>Penicillins</p> <p>Azithromycin</p> <p>Chloramphenicol</p> <p>Florfenicol</p> <p>Clindamycin</p> <p>Metronidazole</p>
Soft-tissue infection	<p>Penicillins (i.e., amoxicillin-clavulanate)</p> <p>Cephalosporins</p> <p>Clindamycin or metronidazole (vs. anaerobes)</p> <p>Tetracycline</p> <p>Trimethoprim-sulfa</p> <p>Azithromycin</p> <p>Marbofloxacin</p> <p>Enrofloxacin</p> <p>Enrofloxacin with metronidazole (vs. polymicrobial aerobic and anaerobic infections)</p>

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Respiratory tract	Penicillins
	Cephalosporins
	Tetracyclines
	Trimethoprim-sulfa
	Azithromycin
	Chloramphenicol
	Florfenicol
	Enrofloxacin (vs. <i>Mycoplasma</i> , etc.)
	Tetracycline (vs. <i>Mycoplasma</i> and <i>Chlamydia</i>)
	Macrolides (vs. <i>Mycoplasma</i>)
	Clindamycin (vs. anaerobes)
	Metronidazole (vs. anaerobes)
Alimentary tract	Trimethoprim-sulfa
	Enrofloxacin
	Cephalosporins
	Amoxicillin
	Tetracyclines
	Metronidazole (vs. anaerobes)
	Neomycin
Skin	Amoxicillin-clavulanate
	Azithromycin
	Cephalosporins
	Erythromycin
	Enrofloxacin
	Marbofloxacin
	Trimethoprim-sulfa
	Lincomycin

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Bone and/or joint	Cephalosporins	553
	Extended-spectrum penicillins	
	Fluoroquinolones	
	Azithromycin	
	Aminoglycosides	
	Lincosamides	
Urinary tract	Penicillins with clindamycin (vs. anaerobes)	
	Third-generation cephalosporins with clindamycin (vs. anaerobes)	
	Penicillins (ampicillin, amoxicillin, amoxicillin-clavulanate)	
	Cephalosporins (cephalexin, cefedroxil, cephazolin)	
	Trimethoprim-sulfa	
	Sulfisoxazole	
Central nervous system	Fluoroquinolones	
	Tetracycline	
	Chloramphenicol (encephalitis)	
	Florfenicol	
	Azithromycin	
	Trimethoprim-sulfa	
Reproductive tract	Metronidazole (vs. anaerobes)	
	Fluoroquinolones (meningitis)	
	Penicillins (inflammation)	
	Third-generation cephalosporins	
	Chloramphenicol	
	Florfenicol	
	Trimethoprim-sulfa	
	Enrofloxacin	
	Amoxicillin-clavulanate	
	Clindamycin (vs. anaerobes)	

- a Definitive therapy should be based on bacterial culture and sensitivity and host species involved.
- b Modified from Allen DG, Pringle JK, Smith D. *Handbook of Veterinary Drugs*. JB Lippincott, Philadelphia, 1993; Gilbert DN, Moellering RC Jr, Sande MA. *The Sanford Guide to Antimicrobial*

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Therapy 2003. ed. 33. Antimicrobial Therapy, Inc, Hyde Park, VT, 2003; and Prescott JF, Baggot JD, Walker RD (eds). *Antimicrobial Therapy in Veterinary Medicine*. Iowa State University, Ames, IA, 2000.

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APPENDIX 105 Antimicrobial combination therapies commonly used in exotic animals.^a

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Drug	Synergistic or Combination Drug
Aminoglycoside ^b (amikacin, gentamicin)	Penicillins (carbenicillin, piperacillin, ticarcillin, amoxicillin, ampicillin), cephalosporins, trimethoprim-sulfa, lincomycin, metronidazole, fluoroquinolones
Amoxicillin	Clavulanate
Cephalosporin	Aminoglycosides, ^b clindamycin, fluoroquinolones, metronidazole, semi-synthetic penicillins
Clindamycin	Penicillins, third-generation cephalosporins, enrofloxacin
Fluoroquinolone (enrofloxacin, ciprofloxacin, marbofloxacin)	Aminoglycosides, ^b third-generation cephalosporins, extended-spectrum penicillins, clindamycin, metronidazole
Lincomycin	Spectinomycin, aminoglycosides ^b
Metronidazole	Amikacin, azithromycin, carbenicillin, cefazolin, cefotaxime, chloramphenicol, enrofloxacin, marbofloxacin, gentamicin, others as indicated
Penicillins (carbenicillin, piperacillin, ampicillin)	Aminoglycosides, ^b fluoroquinolones
Penicillins, early-generation	Aminoglycosides, ^b third-generation cephalosporins
Ticarcillin	Clavulanate
Trimethoprim	Sulfadiazine, sulfamethoxine
Tylosin	Oxytetracycline

a Indicated when synergy is advantageous in definitive therapy, to treat polymicrobial infections, to broaden empiric coverage, or to attempt to prevent the development of antimicrobial resistance.

b Generally amikacin, occasionally gentamicin, etc.

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APPENDIX 106 Selected laboratories conducting avian and reptile diagnostic procedures.^a

Laboratory	Test/Procedure
<p>AMR Laboratories</p> <p>P.O. Box 656</p> <p>Plymouth Meeting, PA 19462, USA</p> <p>(877) 424-1212</p>	<p>Avian: Sex determination</p>
<p>Animal Health Diagnostic Laboratory</p> <p>Michigan State University</p> <p>4125 Beaumont Road</p> <p>Lansing, MI 48909, USA</p> <p>(517) 353-1683</p>	<p>Avian: Microbiology, <i>Chlamydia</i>, <i>Mycoplasma</i>, poxvirus, Pacheco's virus, other viruses, necropsy, histopathology, blood lead, other toxins</p>
<p>Antech Diagnostics</p> <p>10 Executive Boulevard</p> <p>Farmingdale, NY 11735, USA</p> <p>(800) 745-4725</p> <p>(800) 872-1001</p>	<p>Avian: Hematology, chemistries, microbiology, <i>Mycoplasma</i>, <i>Chlamydia</i>, <i>Chlamydophila</i>, psittacine beak and feather disease virus, polyomavirus, sexing</p> <p>Reptiles: Hematology, chemistries, microbiology, <i>Mycoplasma</i>, sexing (green iguanas)</p>
<p>Avian Biotech International</p> <p>Animal Genetics, Inc.</p> <p>1336 Timberlane Road</p> <p>Tallahassee, FL 32312, USA</p> <p>(850) 386-1145</p> <p>(800) 514-9672</p>	<p>Avian: Sex determination (recombinant DNA), polyomavirus, psittacine beak and feather disease, <i>Chlamydophila</i>, papilloma virus, pigeon circovirus, Pacheco's virus, avian influenza, West Nile virus, avian mycobacteriosis, <i>Cryptosporidium</i>, giardia, aspergillosis, <i>Candida</i></p>
<p>Avian & Exotic Animal Clin Path Labs</p> <p>2712 North Highway 68</p> <p>Wilmington, OH 45177, USA</p> <p>(937) 383-3347</p> <p>(800) 350-1122</p>	<p>Avian: Hematology, chemistries, bile acid, electrophoresis, histopathology, cytology, microbiology, <i>Chlamydia</i>, <i>Mycoplasma</i>, parasitology, giardia, blood lead and zinc, iron assays</p> <p>Reptiles: Similar to above; <i>Cryptosporidium</i></p>

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<p>Avian and Wildlife Laboratory Division of Comparative Pathology</p> <p>University of Miami School of Medicine</p> <p>P.O. Box 016960 (R-46)</p> <p>Miami, FL 33101, USA</p> <p>(305) 243-6700</p> <p>(800) 596-7390</p>	<p>Avian: Hematology, chemistries, protein electrophoresis, histopathology, microbiology, serology (<i>Chlamydophila</i>, <i>Aspergillus</i>, <i>Sarcocystis</i>, <i>Cryptosporidium</i>), psittacine beak and feather disease virus, polyomavirus</p> <p>Reptiles: Hematology, chemistries, histopathology, microbiology</p>	555
<p>California Avian Laboratory</p> <p>P.O. Box 5647</p> <p>El Dorado Hills, CA 95762, USA</p> <p>(916) 933-0898</p> <p>(877) 521-6004</p>	<p>Avian: Hematology, chemistries, cytology, histopathology, necropsy, microbiology, <i>Chlamydia</i>, <i>Mycoplasma</i>, parasitology, radiology consultation</p> <p>Reptiles: Similar to above</p>	556
<p>Clinical Virology Laboratory</p> <p>Room A239</p> <p>College of Veterinary Medicine</p> <p>University of Tennessee</p> <p>2407 River Drive</p> <p>Knoxville, TN 37996, USA</p> <p>(865) 974-5643</p>	<p>Reptiles: Ophidian paramyxovirus</p>	
<p>Comparative Toxicology Laboratories</p> <p>College of Veterinary Medicine</p> <p>Kansas State University</p> <p>Manhattan, KS 66506, USA</p> <p>(785) 532-5679</p>	<p>General toxicologic analyses: heavy metals, pesticides, mycotoxins, other environmental contaminants</p>	
<p>Diagnostic Laboratory</p> <p>College of Veterinary Medicine</p> <p>P.O. Box 5786</p> <p>Ithaca, NY 14852, USA</p> <p>(670) 253-3900</p>	<p>Avian: West Nile virus</p>	

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<p>Infectious Diseases Laboratory</p> <p>Department of Medical Microbiology</p> <p>College of Veterinary Medicine</p> <p>510 DW Brooks Drive</p> <p>University of Georgia</p> <p>Athens, GA 30602, USA</p> <p>(706) 542-8092</p>	<p>Avian: Psittacine beak and feather disease, polyomavirus, <i>Chlamydophila</i>, Pacheco's disease, avian virus isolation, sex identification</p> <p>Reptiles: <i>Salmonella</i> spp. (DNA probe)</p>	
<p>Jacobson, Elliot, DVM, PhD</p> <p>Dept. of Small Animal Clinical Sciences</p> <p>College of Veterinary Medicine</p> <p>University of Florida</p> <p>P.O. Box 100126</p> <p>Gainesville, FL 32610, USA</p> <p>(352) 392-4700 (x 5700)</p>	<p>Reptiles: Ophidian paramyxovirus</p>	
<p>Johne's Testing Center</p> <p>University of Wisconsin</p> <p>School of Veterinary Medicine</p> <p>Room 4230</p> <p>2015 Linden Drive West</p> <p>Madison, WI 53706, USA</p> <p>(608) 265-6463</p>	<p>Avian: <i>Mycobacterium avium</i> culture</p>	556
<p>Mycoplasma Research Laboratory</p> <p>University of Florida</p> <p>1600 S.W. Archer Road</p> <p>BSB 350</p> <p>Gainesville, FL 32610, USA</p> <p>(352) 392-4700 (x3968)</p>	<p>Reptiles: Tortoise <i>Mycoplasma</i> testing</p>	557

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<p>National Veterinary Services Laboratory</p> <p>APHIS</p> <p>USDA</p> <p>P.O. Box 844</p> <p>(Send specimens to 1800 Dayton St)</p> <p>Ames, IA 50010, USA</p> <p>(515) 663-7266</p> <p>Note: Submission of samples requires approval by the federal veterinarian-in-charge of your area</p>	<p>Avian: Microbiology culture and serology (aspergillosis, avian adenovirus, herpes, influenza, paramyxovirus, Pacheco's virus, poxvirus, reovirus, <i>Chlamydia</i>, <i>Mycoplasma</i>, <i>Mycobacterium</i>, <i>Salmonella</i>, Newcastle disease, etc.), toxicology, parasitology</p> <p>Reptiles: Similar to above</p>
<p>Northwest ZooPath</p> <p>654 West Main Street</p> <p>Monroe, WA 98272, USA</p> <p>(360) 794-0630</p>	<p>Pathology</p>
<p>Quest Diagnostics</p> <p>APL Veterinary Laboratories</p> <p>4230 S. Burnham Avenue</p> <p>Las Vegas, NV 89119, USA</p> <p>(702) 733-7866</p> <p>(800) 433-2750</p>	<p>Avian: Hematology, chemistries, pathology, aspergillosis AGID serology (also other fungal diseases), <i>Chlamydia</i>, <i>Mycoplasma</i> and <i>Mycobacterium</i> culture, TSH stimulation</p> <p>Reptiles: Similar to above</p>
<p>The Raptor Center</p> <p>National Center for Avian Clinical Services</p> <p>College of Veterinary Medicine</p> <p>1920 Fitch Avenue</p> <p>St. Paul, MN 55108, USA</p> <p>(612) 624-4745</p>	<p>Avian: Aspergillosis ELISA test</p>
<p>Research Associates Laboratory</p> <p>14556 Midway Road</p> <p>Dallas, TX 75224, USA</p> <p>(972) 960-2221</p>	<p>Avian: Psittacine beak and feather disease virus, Pacheco's virus, polyomavirus, <i>Chlamydophila</i>, sex determination</p>

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<p>Texas Veterinary Medical Diagnostic Laboratory</p> <p>Texas A&M University</p> <p>P.O. Drawer 3040</p> <p>College Station, TX 77841–3040, USA</p> <p>(409) 845–3414</p> <p>(888) 646–5623</p> <p>(Send specimens to 1 Sippel Road College Station, TX 77843, USA)</p>	<p>Avian: <i>Chlamydophila</i>, Pacheco's virus, polyomavirus, chemistries, necropsy, histopathology, cytology, microbiology, serology, toxicology</p> <p>Reptiles: Similar to above</p>	557
<p>Thoen, Charles O, DVM, PhD</p> <p>Department of Microbiology, Immunology, and Preventive Medicine</p> <p>Veterinary Medicine Complex</p> <p>Iowa State University</p> <p>Ames, IA 50011, USA</p> <p>(515) 294–7608</p>	<p>Avian: Tuberculosis ELISA (available for some species), lymphocyte blastogenic assays</p>	558
<p>Veterinary Medical Diagnostic Laboratory</p> <p>College of Veterinary Medicine</p> <p>University of Missouri</p> <p>P.O. Box 6023</p> <p>Columbia, MO 65205, USA</p> <p>(573) 882–6811</p>	<p>General toxicologic analyses, pesticide screen, heavy metal screen, lead, mycotoxin screen</p>	
<p>Veterinary Molecular Diagnostics, Inc.</p> <p>5989 Meijer Drive, Suite 5</p> <p>Milford, OH 45150, USA</p> <p>(513) 576–1808</p>	<p>Avian: Psittacine beak and feather disease, West Nile virus, <i>Aspergillus</i> spp., psittacid herpes virus, <i>Chlamydophila</i>, avian polyomavirus, <i>Mycoplasma</i>, <i>Bordetella avium</i>, sex determination</p>	
<p>Zoo/Exotic Pathology Service</p> <p>2825 KOVR Drive</p> <p>West Sacramento, CA 95605, USA</p> <p>(916) 725–5100</p> <p>(800) 457–7981</p>	<p>Pathology</p>	

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Zoogen, Inc	Avian: Sex determination (recombinant DNA)
1902 East 8 th Street	
Davis, CA 95616, USA	Reptiles: Sex determination (green iguanas)
(530) 750-5757	
(800) 955-2473	

a Similar services are also offered at most of these laboratories for other exotic animals.

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13.1 APPENDIX 107 Determining the basal metabolic rate of animals.

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The following information is provided so that drugs can be allometrically scaled for different species and to assist in calculating metabolic need for nutritional requirements and fluid therapy.

BMR (basal metabolic rate)

- BMR differs between species.
- The general equation to calculate BMR^a is: $BMR = kW^{0.75}$

BMR = kcal/kg/d

k = kcal/kg constant (nonpasserines = 78, passerines = 129, placental mammals = 70, marsupials = 49, reptiles at 37° C = 10)

W = weight in kg

- Other equations have been determined for passerine and nonpasserine birds in relation to the daylight cycle. These cycles are termed “active phase” and “rest phase.” However, results are similar to the above formula.

Phase	Passerine	Nonpasserines
Active phase	$BMR = (140.7)W^{0.704}$	$BMR = (91)W^{0.729}$
Rest phase	$BMR = (113.8)W^{0.726}$	$BMR = (72)W^{0.734}$

- Maintenance energy requirement (MER) = (kcal/d) = (1.5 BMR)

In the bird, the MER can then be adjusted for health status as follows^b:

Physical inactivity	0.7–0.9 × MER
Starvation	0.5–0.7 × MER
Hypometabolism	0.5–0.9 × MER
Elective surgery	1.0–1.2 × MER
Mild trauma	1.0–1.2 × MER
Severe trauma	1.1–2.0 × MER
Growth	1.5–3.0 × MER
Sepsis	1.2–1.5 × MER
Burns	1.2–2.0 × MER
Head injuries	1.0–2.0 × MER

a Sedgwick C, Pokras M, Kaufman G. Metabolic scaling: using estimated energy costs to extrapolate drug doses between different species and different individuals of diverse body sizes. *Proc Annu Conf Am Assoc Zoo Vet* 249-254, 1990.

b Quesenberry KE, Mauldin G, Hillyer E. Review of method of nutritional support in hospitalized bird. *First Conf Euro Comm Assoc Avian Vet* 243-254, 1991.

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13.2 APPENDIX 108 Allometric scaling of drugs used in animals.

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Although allometric scaling provides a means to calculate a drug in terms of an animal's basal metabolic rate (BMR; see [Appendix 107](#)), pharmacokinetically-derived data are the preferred source of information for the dose and frequency. Allometric scaling can complement or be an alternative to empirical dosing and extrapolation from domestic animal and human dosing. Scaling does not guarantee that the dosage would be efficacious, nontoxic, safe, or correct. All allometrically scaled dosages, therefore, should be reviewed by the practitioner before administration. Use of a conventional dosage is preferred over an allometric dose when the allometric dose seems disproportionate. The reader is referred to other sources of information concerning the use of allometric scaling.^{ab}

$$\text{BMR in kcal/d} = kW^{0.75}$$

k = kcal/kg/d constant (nonpasserines = 78, passerines = 129, placental mammals = 70, marsupials = 49, reptiles at 37° C = 10)

W = weight in kg

The BMR needs to be calculated for avian species for which a dosage is not known as well as for species in which the drug is routinely used. For example, a dosage for enrofloxacin needs to be calculated for a 30 g canary patient (BMR_p) on the basis of a model (known) dosage of 7.5 mg/kg q12h for an Amazon parrot (BMR_m) weighing 250 g.

1. Model BMR = $\text{BMR}_m = (78 \text{ kcal/kg/d}) (0.250 \text{ kg})^{0.75} = 27.6 \text{ kcal/d}$
2. Model energy cost = $kW^{-0.25} = (78 \text{ kcal/kg/d}) (0.250 \text{ kg})^{-0.25} = 110 \text{ kcal/d}$
3. Model dose = 7.5 mg/kg
4. Model dose interval = q12h
5. Model treatment dose = (wt in kg) (dose) = $(0.250 \text{ kg}) (7.5 \text{ mg/kg}) = 1.875 \text{ mg}$
6. BMR_m dose = (model treatment dose)/(BMR_m) = $(1.875 \text{ mg})/(27.6 \text{ kcal/d}) = 0.068 \text{ mg/kcal/d}$
7. Patient BMR = $\text{BMR}_p = (129 \text{ kcal/kg/d}) (0.030 \text{ kg})^{0.75} = 9.3 \text{ kcal/d}$
8. Patient energy cost = $kW^{-0.25} = (129 \text{ kcal/kg/d}) (0.030 \text{ kg})^{-0.25} = 310 \text{ kcal/d}$
9. Patient treatment dose = (BMR_m dose) (BMR_p) = $(0.068 \text{ mg/kcal/d}) (9.3 \text{ kcal/d}) = 0.63 \text{ mg}$

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10. Patient dose = (patient treatment dose)/(wt in kg) = (0.63 mg)/(0.030 kg) = 21 mg/kg

11. Patient treatment interval = [(patient energy cost/model energy cost)/(model dose interval)]⁻¹ = [(310 kcal/d /110 kcal/d)/(12 hours)]⁻¹ = 4.26 hours

12. Final dose = 21 mg/kg q4h

a Frazier DL, Jones MP, Orosz SE. Pharmacokinetic considerations of the renal system in birds: Part II. Review of drugs excreted by renal pathways. *J Avian Med Surg* 9:104-121, 1995.

b Jensen JM, Johnson JH, Weiner ST. *Husbandry and Medical Management of Ostriches, Emus and Rheas*. Wildlife and Exotic Animal TeleConsultants, College Station, TX, 1992.

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APPENDIX 109 Common abbreviations used in prescription writing.

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a.c.	before meals
a.d.	right ear
ad lib	at pleasure
adm	administer
aq	water
a.s.	left ear
a.u.	both ears
b.i.d.	twice a day
c.	with
cap(s)	capsule(s)
cc	cubic centimeter
disp	dispense
fl oz	fluid ounce
g (gm)	gram
gr	grain
gtt(s)	drop(s)
h (hr)	hour
h.s.	at bedtime
IM	intramuscularly
inj	inject
IP	intraperitoneally
IV	intravenously
kg	kilogram
lb	pound
mg	milligram
ml	milliliter
o.d.	right eye
o.s.	left eye
o.u.	both eyes
oz	ounce
p.c.	after meals
PO (p.o.)	per os
prn (p.r.n.)	as needed
q. (q)	every
q.d.	every day
q4h	every 4 hours, etc.
q24h	once a day
q.i.d.	four times a day
q.o.d.	every other day
q.s.	a sufficient quantity
®	trademarked name
SC (SQ)	subcutaneously
Sig:	instructions to patient
sol'n	solution
stat	immediately
susp	suspension
tab(s)	tablet(s)
Tbs	tablespoon
t.i.d.	three times a day
tsp	teaspoon
ut dict.	as directed

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13.3 APPENDIX 110 Common weight, liquid measure, and length conversions.

Weights

1 milligram (mg) = 1000 micrograms (mcg or μ g)

1 grain (gr) = 64.8 mg (~65 mg)

1 gram (g) = 15.43 grains (~15 grains) = 1000 mg

1 kilogram (kg) = 1000 g

1 ounce (oz) = 28.35 g (~30 g)

1 pound (lb) = 454 g = 16 oz. = 0.45 kg

2.2 pound = 1 kg

Liquid measures

1 drop = 0.05 (1/20) milliliter (ml)

1 cubic centimeter (cc) = 1 ml

1 liter (L) = 1000 ml

1 teaspoon (tsp) = 5 ml

1 tablespoon (Tbs) = 15 ml

1 fluid ounce (fl oz) = 29.57 ml (~30 ml)

1 quart = 2 pints = 32 fl oz (~0.95 L)

1 gallon = 4 quarts = 3.785 L

1 cup = 8 fl oz = 237 ml = 16 Tbs

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Linear measures

1 millimeter (mm) = 0.039 inches (in)

1 centimeter (cm) = 0.39 in

1 meter (m) = 39.37 in

1 inch (in) = 2.54 cm

1 foot (ft) = 30.48 cm

1 yard (yd) = 91.44 cm

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APPENDIX 111 Equivalents of Celsius (centigrade) and Fahrenheit temperature scales.

°C	°F
0	32.0
1	33.8
2	35.6
3	37.4
4	39.2
5	41.0
6	42.8
7	44.6
8	46.4
9	48.2
10	50.0
11	51.8
12	53.6
13	55.4
14	57.2
15	59.0
16	60.8
17	62.6
18	64.4
19	66.2
20	68.0
21	69.8
22	71.6
23	73.4
24	75.2
25	77.0
26	78.8
27	80.6
28	82.4
29	84.2
30	86.0
31	87.8
32	89.6
33	91.4
34	93.2
35	95.0
36	96.8
37	98.6
38	100.4
39	102.2
40	104.0
41	105.8
42	107.6
43	109.4
44	111.2
45	113.0
46	114.8
47	116.6
48	118.4
49	120.2

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122.0

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APPENDIX 112 System of International Units conversion factors of clinical chemistries commonly used in exotic animal medicine.^a

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Component	Conventional (USA) Units	Conversion Factor	SI Unit
Alkaline phosphatase	u/L	1.0	IU/L
ALT (SGPT)	u/L	1.0	IU/L
Albumin	g/dl	10	g/L
Ammonia (NH ₄)	μg/dl	0.5871	μmol/L
Amylase	u/L	1.0	IU/L
AST (SGOT)	u/L	1.0	IU/L
Bilirubin	mg/dl	17.10	μmol/L
Calcium	mg/dl	0.2495	mmol/L
Carbon dioxide	mEq/L	1.0	mmol/L
Chloride	mEq/L	1.0	mmol/L
Cholesterol	mg/dl	0.02586	mmol/L
Cortisol	μg/dl	27.59	nmol/L
Creatine kinase	u/L	1.0	IU/L
Creatinine	mg/dl	88.40	μmol/L
Fibrinogen	mg/dl	0.01	g/L
Glucose	mg/dl	0.05551	mmol/L
Iron	μg/dl	0.1791	μmol/L
Lipase			
Sigma Tietz	u/dl	280	IU/L
Cherry Crandall	u/L	1.0	IU/L
Lipid, total	mg/dl	0.01	g/L
Osmolality	mOsm/kg	1.0	mmol/kg
Phosphate (as inorganic P)	mg/dl	0.3229	mmol/L
Potassium	mEq/L	1.0	mmol/L
Protein (total)	g/dl	10	g/L
Sodium	mEq/L	1.0	mmol/L
Thyroxine (T ₄)	μg/dl	12.87	nmol/L
Urea nitrogen	mg/dl	0.3570	mmol/L ^b

^a Modified from *The Merck Veterinary Manual* (8th edition, 1998), as adapted from The SI Manual in Health Care, Metric Commission, Canada, 1981.

^b Urea.

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14 ABBREVIATIONS

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ALT	alanine aminotransferase
AP	alkaline phosphatase
AST	aspartate aminotransferase
BUN	blood urea nitrogen
BW	body weight
CBC	complete blood count
cc	cubic centimeter
CPK	creatine phosphokinase
d	day
DM	dry matter
DMSO	dimethyl sulfoxide
EpiCe	epicoelomic
FSH	follicle-stimulating hormone
g	gauge
GGT	gamma-glutamyltransferase
GnRH	gonadotropin-releasing hormone
h, hr	hour
Hb	hemoglobin
HCG	human chorionic gonadotropin
IA	intraarticular
ICe	intracoelomic
IM	intramuscularly
IO	intraosseous
IP	intraperitoneally
IPPV	intermittent positive pressure ventilation
IT	intratracheally
IV	intravenously
IU	international units
kg	kilogram
L	liter
LDH	lactate dehydrogenase
LH	luteinizing hormone
LRS	lactated Ringer's solution
MAC	mean alveolar concentration
MCH	mean corpuscular hemoglobin
MCHC	mean corpuscular hemoglobin concentration
MCV	mean corpuscular volume
mg	milligram
min	minute
mo	month
NRBC	nucleated red blood cells
PCV	packed cell volume
PD	pharmacologic data
PO	orally
prn	as needed
q	every
RBC	red blood cell(s)
SC	subcutaneously
sec	second
U	unit
vol	volume
WBC	white blood cell(s)

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wk

week